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NOTES

FOR

STUDENTS IN CHEMISTRY;

BEING A SYLLABUS OF CHEMISTRY AND PRACTICAL CHEMISTRY.

COMPILED FROM THE MANUALS OF GMELIN, MILLER, FOWNES, BERZELIUS, NAQUET, GERHARDT, GORUP-BESANEZ, ETC.

BY

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PREFACE.

Soon after my appointment to the Chair of Chemistry at St. Mary's Hospital in 1854, I noticed that the chief part of the lecture-time was occupied by the most diligent students in taking notes of the various formulæ and reactions which were from time to time stated; and that they were thereby prevented from paying continuous attention to the course of the Lecture, and its illustrative experiments

To remedy this evil, I published in 1855 the first edition of my "Notes for Students," in which I endeavoured to supply all the information necessary to form a connecting basis for the teaching in the lectures.

A new feature of the present syllabus is an Appendix giving the doses of the chief chemical preparations of the "Materia Medica." This addition was suggested to me by one of my present colleagues, Dr. Clapton, and carried out by my friend Mr. H. B. Donkin.

Albert J. Bernays.

Chemical Laboratory,
St. Thomas's Hospital Medical College,
January, 1870

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NOTES FOR STUDENTS IN CHEMISTRY.

MANIFOLD as are the substances which we meet with on every hand, there are but few bodies which cannot be resolved by heat or otherwise into simpler forms. Those bodies which resist all attempts at decomposition are called ELEMENTS or simple bodies.

The elements are sixty-four in number; they may be divided for convenience into NON-METALLIC ELEMENTS and into METALS. The non-metallic elements are more or less imperfect conductors of heat and electricity, and their chief tendency is to unite with the element Hydrogen and to form acid compounds.

The elements are very unevenly distributed throughout the earth and the air. The most abundant constituents of this globe are Oxygen, Silicon, Aluminum, Iron, Calcium, Magnesium, Sodium, and Potassium.

Those elements and their compounds which are either little known, or of less importance, will be bracketed, so that they may be passed over by those students who do not require information with reference to them.

The non-metallic Elements are 13 in number: **five are gaseous**—viz., HYDROGEN, OXYGEN, NITROGEN, CHLORINE, and FLUORINE; **one is a liquid**, BROMINE; the other **seven are solids**—viz., CARBON, SILICON, SULPHUR, SELENIUM, PHOSPHORUS, IODINE, and BORON.

Chemists are in the habit of representing the elements by symbols: thus, the initial letters of the Latin names represent the smallest proportion in which one element will unite with another. When two elements commence with the same initial letters, the one is distinguished from the other by an affix. Thus, **S** stands for Sulphur; **Se** for Selenium; **Si** for Silicon.

Each element is supposed to consist of very minute particles, which cannot be further sub-divided; these particles are called *atoms*, from the Greek *ἀ* privative, and *τεμνω*, *temno*, I cut. The atoms of the various elements possess distinct weights; thus the

atom of OXYGEN is found to be sixteen times heavier than the atom of HYDROGEN. Now, as HYDROGEN is accepted as unity, the atomic weight of HYDROGEN being **1**, that of OXYGEN is **16**, of NITROGEN **14**, of CHLORINE **35.5**, of FLUORINE **19**. **One gramme of Hydrogen, at the normal temperature and pressure, fills a volume of 11.19 litres.** The same space is occupied by **16** grammes of Oxygen, **14** grammes of Nitrogen, **35.5** grammes of Chlorine, and **19** grammes of Fluorine.

Equal volumes of most of the elementary gases, when compared under the same conditions of temperature and pressure, are supposed to contain the same number of atoms.

The smallest proportion of an element found in combination is called its **Atom**, whilst the smallest proportion of it in a free state is called its **Molecule**. The atom of HYDROGEN being **H = 1**, its molecule must be **HH** or $\mathbf{H_2 = 2}$. So also with OXYGEN, its molecule must be **OO** or $\mathbf{O_2 = 32}$.

Every compound consists of the smallest cluster of molecules; thus WATER or HYDROGEN OXIDE, being a compound of two atoms of HYDROGEN with one atom of OXYGEN, is represented by the symbol $\mathbf{H_2O = 18}$. The atomic weight of compounds, capable of existing in the form of vapour or gas, occupies the space of two volumes of our standard HYDROGEN; consequently, if we desire to know the specific weight of a compound which occupies the space of two volumes, we must halve its atomic weight in order to compare it with H = 1.

Thus, HYDROGEN (1 vol.) unites with CHLORINE (1 vol.) to constitute **2** volumes of HYDROCHLORIC ACID: the symbol of that compound being **HCl**, and its atomic weight **36.5**, its SPECIFIC WEIGHT must be **18.25** when compared with 1 vol. of Hydrogen.

Again: HYDROGEN (2 vols.) unites with OXYGEN (1 vol.) to form **2 vols.** of WATERY VAPOUR $\mathbf{H_2O}$: the SPECIFIC WEIGHT of 1 vol. of H_2O, as vapour, must be 9.

Further: HYDROGEN (3 vols.) unites with NITROGEN (1 vol.) to form **2 vols.** of AMMONIA $\mathbf{H_3N}$; the SPECIFIC WEIGHT of 1 vol. of H_3N must be 8.5.

Lastly: HYDROGEN (4 vols.) unites with CARBON (volume unknown, as it cannot be volatilized) to form **2 vols.** of MARSH-GAS $\mathbf{H_4C}$. When 1 vol. of this gas is weighed, it is found to be **8** times heavier than 1 vol. of Hydrogen; its SP. WEIGHT or SP. GRAVITY must be 8.

Whenever a GROUP OF ELEMENTS behaves like an ELEMENT, it is called a **radical**, and the same term "atom" is applied to such a group. Thus, CARBON and NITROGEN unite to form CYANOGEN, and the symbol for CYANOGEN expresses the weight of its atom; **CN** or **Cy** = 26 expresses the **atom**; $C_2N_2 = 52$ represents the MOLECULE. In combination, CN exists with 1 atom of Hydrogen,

as HYDRO-CYANIC ACID HCN = 27 : but the volume-weight of its vapour must be half the atomic weight, therefore 13.5.

In the chemical notation adopted in this book, the formulæ of compounds, which can exist in the form of gas or vapour, always denote 2 volumes, unless expressly stated to the contrary.

The elements themselves are called **Monads, Dyads, Triads, Tetrads, Pentads**, or **Hexads**, according to the amount of HYDROGEN they unite with in their chief combination, or the character of the element which they can replace in combination.

A **tetrad** may also assume the character of a **dyad**, and a **triad** sometimes that of a **monad**, sometimes that of a **pentad**. In COMBINATIONS, **one** DYAD can unite with or displace another DYAD or **two** MONADS; a TRIAD can displace **three** monads or **one** triad. **One** TETRAD can unite with **four** MONADS or **two** DYADS, and can also displace similar amounts of different elements.

Table of Atomic Weights.

Monads or Monatomic elements.

Hydrogen	H = 1	Natrium	Na = 23
Chlorine	Cl = 35.5	Caesium	Cs = 133
Bromine	Br = 80	Rubidium	Rb = 85.5
Iodine	I = 127	Lithium	L = 7
Fluorine	F = 19	Argentum	Ag = 108
Kalium	K = 39	Thallium	Tl = 204

Dyads or Diatomic elements.

Oxygen	O = 16	Palladium	Pd = 106.5
Sulphur	S = 32	Rhodium	R = 104.3
Selenium	Se = 79.5	Manganesium	Mn = 55
Tellurium	Te = 129	Ferrum	Fe = 56
Barium	Ba = 137	Cobalt	Co = 59
Strontium	Sr = 87.5	Nickel	Ni = 59
Calcium	Ca = 40	Zinc	Zn = 65
Magnesium	Mg = 24	Cadmium	Cd = 112
Yttrium	Y = 68	Indium	In = 74
Lanthanum	La = 92	Cuprum	Cu = 63.5
Cerium	Ce = 92	Plumbum	Pb = 207
Didymium	D = 96	Hydrargyrum	Hg = 200
Uranium	U = 120		

Triads or Triatomic elements.

Nitrogen	N = 14	Glucinum	G = 9.3
Phosphorus	P = 31	Chromium	Cr = 52.5
Arsenicum	As = 75	Aluminum	Al = 27.5
Stibium	Sb = 122	Bismuth	Bi = 210
Boron	B = 11	Aurum	Au = 196.6

Tetrads or Tetratomic elements.

Carbon	C = 12	Niobium	Nb = 97.5
Silicon	Si = 28	Ruthenium	Ru = 104
Titanium	Ti = 50	Platinum	Pt = 197
Stannum	Sn = 118	Iridium	Ir = 198
Zirconium	Zr = 90	Osmium	Os = 199
Thorinum	Th = 231.5	Tantalum	Ta = 137.6

Hexads or Hexatomic elements.

Molybdenum	Mo = 92	Vanadium	V = 137
Tungsten	W = 184		

A. *The non-metallic elements and their compounds, including Stibium, Arsenicum, Bismuth, Titanium, and Zirconium.*

I.—Hydrogen H_2. $H_2 = 2$.

1. HYDROGEN $H = 1$.—Molecular weight $H_2 = 2$. Monad element: the standard of atomic weights. A colourless, tasteless, and inodorous gas, at least when pure. It is inflammable when heated in air, burning at the expense of atmospheric oxygen and with pale flame to HYDROGEN OXIDE, or WATER H_2O. It is the lightest of all gases, 14.5 × lighter than air; 14 × lighter than nitrogen; 16 × lighter than oxygen, and 35.5 × lighter than chlorine. 11.19 litres of the gas weigh 1 gramme (one litre weighs 0.0896 gramme, called a *crith* by Dr. Hoffman. In these "Notes" preference is given to Dr. Williamson's standard, the weight of 11.19 litres). Water dissolves 1.93 per cent. at 15°C. Hydrogen is found chiefly in combination: with oxygen in water, and in nearly all organic bodies. It is separated from water either by the aid of various metals, or from certain acids by metals, or by electrolysis. 1. From HYDROGEN OXIDE by natrium or sodium: sodium hydrate is found in solution: $Na_2 + 2H_2O = 2NaHO + H_2$. 2. From steam over red-hot ferrum in a gunbarrel: FERROUS-FERRIC OXIDE Fe_3O_4, remains, $4H_2O + 3Fe = Fe_3O_4 + 4H_2$. 3. From sulphuric acid (diluted) by zinc; ZINC SULPHATE $ZnSO_4$, remains: $H_2SO_4 + Zn = ZnSO_4 + H_2$. 4. From hydrochloric acid and zinc, ZINC CHLORIDE $ZnCl_2$, remains: $2HCl + Zn = ZnCl_2 + H_2$. 5. By electrolysis; H_2 separates at the negative pole or zincode.

II.—Oxygen $O = 16$. $O_2 = 32$.

2. OXYGEN $O = 16$.—Molecular weight $O_2 = 32$. Dyad element. Colourless, tasteless, and inodorous gas, uninflammable. The great supporter of combustion. Necessary to decay, germination, putrefaction. Water dissolves 2.99 per cent. at 15°C. The most magnetic of gases; the diurnal variations of the

needle referable to the effects of heat upon it. Atmospheric magnetism is weakened in our latitude east of the meridian by the sun's rays in the morning; the deviation is then towards the west until an hour after noon, when it goes back towards east until eight o'clock; then it remains stationary until sunrise. Oxygen is 16 × heavier than hydrogen: 11.19 litres weigh 16 grammes. In the free state, oxygen is found in the air in ADMIXTURE with nitrogen, constituting 21 per cent. by volume and 23 per cent. by weight of dry air. Combined with hydrogen as hydrogen oxide H_2O, it forms $\frac{8}{9}$ of the weight of the latter. It is a component of nearly all organic bodies and a constituent of most minerals. *Prep.* 1. From MERCURIC OXIDE HgO by heat: $2HgO = Hg_2 + O_2$. 2. From MANGANESE PEROXIDE MnO_2, by heat; MANGANOUS-MANGANIC OXIDE Mn_3O_4, remains. $3MnO_2 = MnO,Mn_2O_3 + O_2$. 3. From BARIUM PEROXIDE BaO_2, by heat; BARIUM OXIDE BaO, remains. $2BaO_2 = 2BaO + O_2$. 4. From HYDROGEN OXIDE H_2O, by electrolysis; OXYGEN separates at the positive pole or platinode. 5. From POTASSIUM CHLORATE $KClO_3$, by heat; POTASSIUM CHLORIDE KCl, remains. $2KClO_3 = 2KCl + 3O_2$. 122.5 grammes of potassium chlorate contain 48 grammes or $3 \times 11.19 = 33.57$ litres of oxygen. 6. From MANGANESE PEROXIDE MnO_2, by SULPHURIC ACID H_2SO_4; MANGANOUS SULPHATE $MnSO_4$, remains: $2MnO_2 + 2H_2SO_4 = 2MnSO_4 + 2H_2O + O_2$. 7. From SULPHURIC ACID H_2SO_4, in vapour at a red heat. The resulting SULPHUROUS ANHYDRIDE SO_2, can be removed by CALCIUM HYDRATE. $2H_2SO_4 = 2SO_2 + 2H_2O + O_2$. 8. From POTASSIUM DI-CHROMATE $K_2Cr_2O_7$, and SULPHURIC ACID H_2SO_4: POTASSIUM CHROME SULPHATE $KCr2SO_4$, remains. $2K_2Cr_2O_7 + 8H_2SO_4 = 4KCr2SO_4 + 8H_2O + 3O_2$. OZONE $O_2O = 48$. The allotropic modification of oxygen; another physical aspect of the same substance. A gas of peculiar odour, like to that emanating through the action of an electrical machine upon the air, which indeed is ozone. 11.19 litres weigh 24 grammes. A great bleaching and disinfecting agent. Sets iodine free from potassium iodide; hence a test-paper containing starch and potassium iodide is blued by ozone $6KI + 3H_2O + O_3 = 6KHO + 3I_2$. Is completely soluble in oil of turpentine. Heated to 290°C., ozone becomes oxygen. *Prep.* Ozone is produced by active vegetation, from decomposition of carbonic anhydride. Also by placing sticks of clean phosphorus in a bottle of moist air.—**Compounds.** 1. WATER OF HYDROGEN OXIDE $H_2O = 18$. Pure water is a colourless liquid in small quantities; otherwise blue. It is also tasteless and inodorous. Maximum density 4°C., freezes at 0°C.; boils at 100°C., bar. 760 m. m.; sp. gr. of water 1 at 4°C.; of ice 0.94. It is composed of 88.89 of **O** and 11.11 of **H**. Density of watery vapour when compared with air 0.623. Latent heat of water 79° C.; latent heat of

steam at 100° C., 537° C. It unites with various salts, molecularly, as water of crystallization, as in EPSOM SALTS $MgSO_4 . 7H_2O$. With metallic oxides, it forms hydrates; $Na_2O + H_2O = 2NaHO$. Anhydrides, it changes into acids: PHOSPHORIC ANHYDRIDE P_2O_5 becomes METAPHOSPHORIC ACID HPO_3. 2. HYDROGEN PEROXIDE H_2O_2 or HYDROXYL. Colourless, syrupy liquid of sp. gr. 1.453. At 22° C. it begins to decompose. Silver oxide Ag_2O is reduced by it; other oxides become more oxydized. The liquid bleaches. *Prep. a.* From BARIUM PEROXIDE BaO_2, WATER and CARBONIC ANHYDRIDE CO_2; BARIUM CARBONATE $BaCO_3$, is also formed. $BaO_2 + H_2O + CO_2 = BaCO_3 + H_2O_2$; *b.* from BARIUM PEROXIDE BaO_2, and HYDROCHLORIC ACID HCl; BARIUM CHLORIDE $BaCl_2$ is also formed. $BaO_2 + 2HCl = BaCl_2 + H_2O_2$.

III. Nitrogen N = 14. $N_2 = 28$.

3. NITROGEN N = 14. Molecular weight 28. Triad element. Colourless, tasteless, inodorous gas. Uninflammable. Does not support combustion. 1.48 per cent. soluble in water at 15° C. Properties negative. 11.19 litres weigh 14 grammes. Discovered by Rutherford in 1772. Also called azote. In a free state, mixed with oxygen, constitutes 79 per cent. by measure and 77 per cent. by weight of dry air. Combined, it is an important constituent of animals and vegetables. *Prep.* 1. By abstraction of oxygen from air: *a.* by the burning of phosphorus in air; phosphoric anhydride P_2O_5 is formed. *b.* by passing air over red-hot copper-turnings, cupric oxide CuO results, and in both cases we obtain NITROGEN. 2. By passing CHLORINE through excess of AMMONIA NH_3, HYDROCHLORIC ACID HCl, remains in solution. $3Cl_2 + 2NH_3 = 6HCl + N_2$. 3. By heating AMMONIUM NITRITE: $NH_4NO_2 = 2H_2O + 4N_2$.

Compounds. Nitrogen with Hydrogen. NITROGEN HYDRIDE or AMMONIA $NH_3 = 17$. Colourless, irrespirable gas, with the odour of "Hartshorn." Inflammable when mixed with oxygen, and kindled; the hydrogen alone burns. 2 vols. of ammonia ($NH_3 = 2$ vols.) require $1\frac{1}{2}$ vols. of O for complete combustion. Condensible under 6.9 atmospheres at 15°C. Solid at − 75°C. Boils at − 38°.5C. Very soluble in water, which absorbs 725 vols. at 15°C. sp. gr. of the liquor ammoniæ 0.884; boils at 54°C. NH_3 is produced in decay, combustion, where bodies contain N and H, and in respiration. Contained in air and brought down by the rain: source of N to plants. Ammonia a volatile alkali. *Prep.* From AMMONIUM CHLORIDE NH_4Cl by CALCIUM HYDRATE CaH_2O_2; CALCIUM CHLORIDE $CaCl_2$ remains. $2NH_4Cl + CaH_2O_2 = CaCl_2 + 2H_2O + 2NH_3$. Ammonia NH_3 unites directly with ACIDS, to form AMMONIUM-SALTS. Thus, with hydrochloric acid HCl, to ammonium chloride NH_4Cl: $NH_3 + HCl = NH_4Cl$. With NITRIC ACID HNO_3 to AMMONIUM NITRATE NH_4NO_3: $NH_3 + HNO_3 = NH_4NO_3$

Although the existence of AMMONIUM NH_4, is problematical, yet, in combination, it produces salts analogous to those of potassium; thus ammonium is considered a hypothetical metal.—**N with O.** 1. NITRIC ANHYDRIDE. $N_2O_5 = 108$. In brilliant, right rhombic prisms; melts at 29.5° C. Boils at 45° C. *Prep.* By passing dry CHLORINE over ARGENTUM NITRATE $AgNO_3$: ARGENTUM CHLORIDE, AgCl remains. $4AgNO_3 + 2Cl_2 = 4AgCl + O_2 + 2N_2O_5$. By water, N_2O_5 becomes NITRIC ACID HNO_3. $N_2O_5 + H_2O = 2HNO_3$. NITRIC ACID $HNO_3 = 63$. Fuming, corrosive liquid of sp. gr. 1.517; boils at 84°.5 C. Stains the skin yellow. It freezes at −40° C. It cannot be distilled without partial decomposition. By heat it is decomposed into NITROGEN PEROXIDE NO_2, water H_2O, and oxygen: $4HNO_3 = 4NO_2 + 2H_2O + O_2$. Monobasic acid. Salts called *Nitrates;* all are soluble in water and deflagrate upon charcoal. POTASSIUM NITRATE KNO_3 is "Saltpetre" or "Nitre." *Prep.* From SODIUM NITRATE $NaNO_3$, by SULPHURIC ACID H_2SO_4; SODIUM HYDROGEN SULPHATE $KHSO_4$, remains in the retort. $NaNO_3 + H_2SO_4 = NaHSO_4 + HNO_3$. N.B. 85 parts of $NaNO_3$ give as much nitric acid as 101 parts of KNO_3. Atomic weight of potassium 39; that of sodium 23.—ORDINARY NITRIC ACID $2HNO_3.3H_2O$. A liquid of sp. gr. 1.42. It may be distilled at 121° C. It fumes in air, and is only somewhat less corrosive than HNO_3. It is a monobasic acid, as it has only one atom of displaceable hydrogen. Action of nitric acid upon the metals:—HNO_3 no action upon gold, platinum, ferrum, and aluminum. Tin or stannum is oxydized to METASTANNIC ACID $H_2Sn_5O_{11}$, $4H_2O$. Stibium or antimony to ANTIMONIC ACID $HSbO_3$; both insoluble in water. Copper into soluble CUPRIC NITRATE $Cu2NO_3$. Mercury into MERCUROUS NITRATE Hg_22NO_3 and MERCURIC NITRATE $Hg2NO_3$. Silver into SILVER NITRATE $AgNO_3$. Zinc into ZINC NITRATE $Zn2NO_3$. Where chemical action takes place, a portion of the acid reduced to a lower condition of oxidation. 2. NITROUS OXIDE $N_2O = 44$. "Laughing gas." Colourless, inodorous gas. Respirable for a time: much employed as an anæsthetic. 11.19 litres weigh 22 grammes. Liquid under a pressure of 50 atmospheres. Solid at −101° C. Boils at −88° C. *Prep.* From AMMONIUM NITRATE NH_4NO_3 by heat at 271° C. into water and nitrous oxide. $NH_4NO_3 = 2H_2O + N_2O$. Also, by the action of zinc upon dilute nitric acid. $10\,HNO_3 + 4Zn + nH_2O = 4Zn2NO_3 + 5H_2O + nH_2O + N_2O$. 3. NITRIC OXIDE $NO = 30$. Colourless gas, irrespirable, uninflammable. 15 × heavier than hydrogen. 11.19 litres weigh 15 grammes. Forms with ferrous sulphate an olive-brown compound $2FeSO_4.NO$: a test for free nitric acid. Also a test for free oxygen, with which it forms an orange-red compound, either NITRIC PEROXIDE NO_2, or NITROUS ANHYDRIDE N_2O_3. *Prep.* of **NO**. By the action of copper-turnings upon nitric acid; $3Cu + 8HNO_3 = 3Cu2NO_3 +$

$4H_2O + 2NO$. Or of quicksilver. $3Hg + 8HNO_3 = 3Hg2NO_3 + 4H_2O + 2NO$. 4. NITROUS ANHYDRIDE N_2O_3. Blue, volatile liquid at $-18°$ C. emitting a red, irritating vapour: at ordinary temperatures an orange-red gas. Mixed with a little water, it forms NITROUS ACID HNO_2. Thus: $N_2O_3 + H_2O = 2HNO_2$. *Prep.* of N_2O_3. By mixing 4 vols. of NITRIC OXIDE NO, with 1 vol. of *oxygen*. $2NO + O = N_2O_3$. Also from ARSENIOUS ANHYDRIDE As_2O_3 and nitric acid: $As_2O_3 + 2HNO_3 + 2H_2O = 2H_3AsO_4 + N_2O_3$. By the action of silver in the cold, we obtain nitrous acid: $2Ag + 3HNO_3 = 2AgNO_3 + H_2O + HNO_2$. When, however, silver is *heated* with nitric acid, nitrous anhydride is given off: $4Ag + 6HNO_3 = 4AgNO_3 + 3H_2O + N_2O_3$. 5. NITROGEN PEROXIDE NO_2 = 2 vols. A liquid under pressure, colourless at $-18°$ C., yellow at 10° C.; boils at 28° C. and forms a deep orange-red vapour. This orange vapour of NO_2 is the chief resultant in air from decomposed nitric acid. In many organic compounds, NO_2 substitutes H atom for atom. *Prep.* 2 ($Pb2NO_3$) by heat = $2PbO + O_2 + 4NO_2$. By water, NO_2 is decomposed into NITRIC ACID and NITRIC OXIDE: $3NO_2 + H_2O = 2HNO_3 + NO$.

IV. Carbon C = 12.

4. CARBON C = 12. A tetrad element existing as a solid in three allotropic modifications. It has not been vaporized: vapour-volume unknown. 1 C^a. The DIAMOND. Sp. gr. 3.33 to 3.55. Hardest gem. Crystallizes in cubes and octohedra, insoluble in all media and infusible. By intense heat, in absence of air into a coke-like substance. Combustible into CARBONIC ANHYDRIDE CO_2 when strongly heated in air or oxygen. 2. C^s. As GRAPHITE or PLUMBAGO: better known as black-lead. Sp. gr. 2.15 to 2.35. In hexagonal, rhombohedral plates. Found in clay-slate, in gneiss, mica, and limestone. Leaden lustre, whence "Black-lead." Conductor of electricity: graphite used as conducting plate in BUNSEN'S battery. 3. C^y. As LAMP-BLACK or AMORPHOUS CARBON, the light-giving principle of flame. "Wood-charcoal," "coke," and "soot" are impure varieties of carbon. Action on putrescent (*Cataplasma carbonis*) and colouring matters.

Compounds. C with H. HYDRIDE OF METHYL or MARSH-GAS CH_4. ETHYLENE, OLEFIANT GAS or HEAVY CARBONETTED HYDROGEN C_2H_4. See ORGANIC CHEMISTRY. **C with O.** *a.* CARBONIC ANHYDRIDE CO_2 = 2 vols. Colourless, uninflammable, inodorous gas: extinguishes combustion. Precipitates lime and baryta water. Liquid under a pressure of 38.5 atmospheres at 0° C.: solid by spontaneous evaporation. Soluble in its own volume of water at 15° C. The "choke-damp" and "after-damp" of mines. A product of respiration, decay, combustion, fermentation, germination, and putrefaction. Air contains 0.035 per

cent.: breathed air 3.5 per cent. of carbonic anhydride. In all waters; in the acidulous waters of Seltzer, Pyrmont, &c. In soda-water, &c. In effervescing wines. Carbonic anhydride is a very heavy gas: 11.19 litres weigh 22 grammes. CO_2 has the properties of an acid: di-basic. Hypothetical formula H_2CO_3. Salts called CARBONATES. Mostly insoluble. CALCIUM CARBONATE $CaCO_3$, the commonest of carbonates, known as limestone, marble, chalk, &c. Potassium, sodium, and ammonium carbonates, are soluble in water: so also are the acid carbonates of barium, strontium, and calcium. *Prep.* of CARBONIC ANHYDRIDE CO_2. 1. In heating calcium carbonate to redness, in the preparation of calcium oxide CaO. $CaCO_3 = CaO + CO_2$. 2. From any carbonate, by acids. Thus, when HYDROGEN CHLORIDE HCl, is poured upon CALCIUM CARBONATE $CaCO_3$, CALCIUM CHLORIDE $CaCl_2$, WATER H_2O and CARBONIC ANHYDRIDE CO_2 result. $CaCO_3 + 2HCl = CaCl_2 + H_2O + CO_2$. Again: $CaCO_3 + 2HNO_3 = Ca2NO_3 + H_2O + CO_2$. 3. Charcoal burns in oxygen to CARBONIC ANHYDRIDE CO_2. *b.* CARBONIC OXIDE CO = 28. 2 vols. Colourless, tasteless, and inodorous gas; burns to carbonic anhydride CO_2 with blue flame. Very poisonous. Water dissolves 2.43 per cent. at 15° C. 11.19 litres of the gas weigh 14 grammes. *Prep.* a. by passing CARBONIC ANHYDRIDE CO_2, over red-hot charcoal. $CO_2 + C = 2CO$. b. By heating OXALIC ACID $H_2C_2O_4,2H_2O$ with SULPHURIC ACID H_2SO_4. $H_2C_2O_4 + H_2SO_4 = H_2SO_4, H_2O + CO_2 + CO$. The CO_2 can be removed by CALCIUM OXIDE CaO or by POTASSIUM HYDRATE KHO. c. By heating ZINC Zn, and CHALK $CaCO_3$, to redness in a gun-barrel. $Zn + CaCO_3 = ZnO + CaO + CO$. d. By heating CARBONIC ANHYDRIDE CO_2 and HYDROGEN H_2: $CO_2 + H_2 = H_2O + CO$. e. By heating POTASSIUM FERROCYANIDE $K_4FeC_6N_6,3H_2O$ with SULPHURIC ACID H_2SO_4 and WATER H_2O. $K_4FeC_6N_6,3H_2O + 3H_2O + 6H_2SO_4 = 2K_2SO_4 + FeSO_4 + 3(NH_4)_2SO_4 + 6CO$. C with N. CYANOGEN C_2N_2 = 52. 2 vols. ORGANIC CHEMISTRY.

V. Sulphur S = 32. S_2 = 64.

5. SULPHUR S = 32. Molecular weight S_2 = 64. A dyad element, found native in Sicily and on the coasts of the Mediterranean. Pale-yellow, brittle solid. Sp. gr. 2.05. Melts at 115° C., and boils at 446° C. Inflammable in air at 260° C. with violet flame to SULPHUROUS ANHYDRIDE SO_2. Found in Sicily, crystallized as an octohedron with rhombic base, and also massive. Soluble in CARBONIC SULPHIDE CS_2; in TURPENTINE $C_{10}H_{16}$ and SULPHUROUS CHLORIDE S_2Cl_2. Insoluble in water. Sulphur forms many natural sulphides. IRON PYRITES FeS_2. MAGNETIC PYRITES Fe_7S_8. COBALT-GLANCE CoSAs. NICKEL-GLANCE NiSAs. BLENDE ZnS. GREENOCKITE CdS. GALENA PbS. SILVER-GLANCE Ag_2S. CINNABAR HgS. COPPER-PYRITES $FeCuS_2$. GREY ANTI-

MONY-ORE Sb_2S_3. ORPIMENT As_2S_3. REALGAR As_2S_2. Sulphur is a notable illustration of the allotropic condition: also di-morphous, crystallizing in two irreconcileable geometrical forms. S^α; already described. Electro-negative. S^β; by fusion of S^α. In oblique prisms of sp. gr. 1.98. Melts at 120° C. *Roll sulphur*. Soluble in CARBONIC SULPHIDE CS_2. Also electro-negative. S^γ; by heating sulphur to nearly 260° C. (amber-coloured liquid at 115° C.; deep-amber at 120° C.; treacle-brown at 180° C.), and sudden cooling; gutta-percha like mass, elastic, of sp. gr. 1.957; insoluble in CS_2; electro-positive. **Compounds.** 1. **S with H.** a. HYDROGEN SULPHIDE OF HYDRO-SULPHURIC ACID $\mathbf{H_2S} = 34$. 2 vols. Colourless gas, smelling of rotten eggs, which evolve it. Narcotic. Inflammable, burning with blue flame to water and sulphurous anhydride: 2 vols. require 3 vols. of O for complete combustion. 11.19 litres of $\mathbf{H_2S}$ weigh 17 grammes. 3.2 vols. are soluble in 1 vol. of water; the solution has a slightly acid reaction. Contained in Harrogate water. Under a pressure of 17 atmospheres $\mathbf{H_2S}$ liquefies; solid at −86° C., boils at −62° C. Emanates from sewers. Absorbed by CALCIUM OXIDE CaO; thus: $CaO + \mathbf{H_2S} = H_2O + CaS$. Decomposed by SULPHUROUS ANHYDRIDE SO_2. Thus: $10SO_2 + 10\mathbf{H_2S} = 5S_2 + 8H_2O$ + PENTA-THIONIC ACID 2 ($H_2S_5O_6$). $\mathbf{H_2S}$ is an important test for metals. Lead-paper or paper soaked in a solution of lead acetate, is immediately blackened by $\mathbf{H_2S}$, owing to the formation of LEAD SULPHIDE PbS, which is black. LEAD ACETATE $Pb2C_2H_3O_2 + \mathbf{H_2S}$ = ACETIC ACID 2 ($HC_2H_3O_2$) + **PbS**. In acid solutions, $\mathbf{H_2S}$ precipitates Pb, Cu, Cd, Hg, Ag, Au, Pt, Pd, Sb, As, Bi, and Sn. *Prep.* of $\mathbf{H_2S}$. *a.* From FERROUS SULPHIDE FeS, by sulphuric acid H_2SO_4; FERROUS SULPHATE $FeSO_4$, and HYDROGEN SULPHIDE $\mathbf{H_2S}$, result. $FeS + H_2SO_4$ + water = $FeSO_4$ + water + $\mathbf{H_2S}$. Also from FERROUS SULPHIDE FeS, by HYDROGEN CHLORIDE HCl. $FeS + 2HCl = FeCl_2 + \mathbf{H_2S}$. *b.* From ANTIMONOUS SULPHIDE Sb_2S_3 by HCl. $6\,HCl + Sb_2S_3 = Sb_2Cl_6 + 3\mathbf{H_2S}$. [HYDROGEN PERSULPHIDE $\mathbf{H_2S_2} = \mathbf{66}$. An oily fluid, analogous to H_2O_2. *Prep.* $3CaH_2O_2 + 6S_2 = CaS_2H_2O_4 + 2H_2O + 2CaS_5$. On filtration and pouring into dilute hydrogen chloride, HYDROGEN PERSULPHIDE $\mathbf{H_2S_2}$, subsides. Also: $CaS_2 + 2HCl = CaCl_2 + \mathbf{H_2S_2}$.] AMMONIUM HYDROGEN SULPHIDE $\mathbf{NH_4HS}$, is the common laboratory test for the metals. Precipitates the metals Al, Cr, Mn, Fe, Zn, Co, and Ni, which are not precipitated by H_2S in acid solutions. NH_4HS becomes yellow by contact with air, owing to the formation of ammonium bi-sulphide − $8NH_4HS + 5O_2 = 2H_2O + 2(NH_4)_2S_2H_2O_4 + 2(\mathbf{NH_4})_2\mathbf{S_2}$. *Prep.* of $\mathbf{NH_4HS}$. By passing H_2S into $H_3N = \mathbf{NH_4HS}$. **S with O.** Unites in 7 proportions. 3 important. *a.* SULPHUROUS ANHYDRIDE $\mathbf{SO_2} = 64$. 2 vols. Colourless, pungent gas, irrespirable, suffocating; ever formed when sulphur is burnt in air. Water dissolves 43.5 per

cent. at 15°.5 C.: the solution behaves like an acid: di-basic H_2SO_3. SULPHUROUS ACID H_2SO_3 forms salts, called SULPHITES: alkaline sulphites are soluble in water. SO_2 is a very heavy gas; 11.19 litres weigh 32 grammes. At −18° C., SO_2 condenses into a colourless liquid. *Prep.* of SO_2. 1. By burning S in $O_2 = SO_2$. 2. By the action of COPPER Cu, upon SULPHURIC ACID H_2SO_4. $Cu + 2H_2SO_4 = CuSO_4 + 2H_2O + SO_2$. Or by Hg upon H_2SO_4. $Hg + 2H_2SO_4 = HgSO_4 + 2H_2O + SO_2$. 3. By heating CHARCOAL C, with H_2SO_4. $C + 2H_2SO_4 = 2H_2O + CO_2 + 2SO_2$. As SO_2 has more powerful affinities than CO_2, the latter does not interfere with the formation of sulphites. Thus: $Na_2CO_3 + SO_2 = CO_2 + Na_2SO_3$. 4. by roasting iron-pyrites in air. $4FeS_2 + 11O_2 = 2Fe_2O_3 + 8SO_2$. This process is much employed in making sulphuric acid. 5. By heating SULPHUR with MANGANESE PEROXIDE MnO_2. $MnO_2 + S_2 = MnS + SO_2$. *b.* SULPHURIC ANHYDRIDE $SO_3 = 80$. As vapour, SO_3 occupies 2 vols. White, silken prisms. Melts at 18°.3 C.; boils at 43°.3 C. Great affinity for water, with which it unites with hissing, to HYDROGEN SULPHATE or SULPHURIC ACID H_2SO_4. $SO_3 + H_2O = H_2SO_4$. SO_3 is contained in NORDHAUSEN SULPHURIC ACID $H_2SO_4 + SO_3$. This acid is a brown, fuming liquid of sp. gr. 1.9. *Prep.* of SO_3. 1. By gently heating Nordhausen acid; SO_3 sublimes. 2. By heating SODIUM ACID SULPHATE $NaHSO_4$. $2NaHSO_4 = H_2O + Na_2SO_4,SO_3$, then: Na_2SO_4,SO_3 by greater heat $= Na_2SO_4 + SO_3$. *c.* HYDROGEN SULPHATE or SULPHURIC ACID $H_2SO_4 = 98$. Is "Oil of vitriol." A heavy fluid of sp. gr. 1.848, with an oil-like consistency. Boils and distils at 338° C. Chars organic bodies. The most powerful acid, except at high temperatures. Di-basic. Many well-known SULPHATES: SODIUM SULPHATE $Na_2SO_4,10H_2O$ is "Glauber salt;" BARIUM SULPHATE $BaSO_4$. is "Heavy spar;" STRONTIUM SULPHATE $SrSO_4$, is "Celestine;" MAGNESIUM SULPHATE $MgSO_4$, $7H_2O$, is "Epsom salt;" ZINC SULPHATE $ZnSO_4,7H_2O$, is "Zinc vitriol;" CUPRIC SULPHATE $CuSO_4,5H_2O$, is "Blue vitriol;" LEAD SULPHATE $PbSO_4$, is "Lead vitriol." All sulphates are soluble in water, except those of barium, strontium, and lead. Sulphuric acid has great affinity for water, hence its use as a "desiccator" for drying gases. It forms with water two hydrates. GLACIAL SULPHURIC ACID H_2SO_4,H_2O, sp. gr. 1.78. Boils at 224° C. GRAHAM'S HYDRATE or SULPHURIC DI-HYDRATE $H_2SO_4,2H_2O$ contains 2 molecules of water. It has a sp. gr. of 1.632; boils at 176° C. **Prep. of oil of vitriol H_2SO_4.** In leaden chambers. At the Felling Works, these chambers are 280' long by 20' wide and 18' high. The essentials in the manufacture are: SO_2; HNO_3; H_2O; and O_2 from the air. Changes: *a.* $SO_2 + 2HNO_3 = 2NO_2 + H_2SO_4$. *b.* SO_2 unites with NO_2 and 1 molecule of water to a crystalline body $SO_2NO_2H_2O$, which by more water is broken up into $NO + H_2SO_4$. *c.* NO unites with oxygen from

the air to NO_2. Thus a very limited supply of HNO_3 acidifies almost unlimited SO_2. The acid on the floor of the chamber is the second hydrate $H_2SO_4,2H_2O$ with a little water. By evaporation in leaden pans, it loses hydratic water and becomes H_2SO_4,H_2O; beyond this point the concentration must be completed in vessels of glass or platinum, till, by the further loss of H_2O, we obtain $\mathbf{H_2SO_4}$, when the process is stopped. Sulphuric acid is used in making: NITRIC ACID. $NaNO_3 + H_2SO_4 = NaHSO_4 + \mathbf{HNO_3}$. CARBONIC ANHYDRIDE. $Na_2CO_3 + H_2SO_4 = Na_2SO_4 + H_2O + CO_2$. HYDROCHLORIC ACID. $NaCl + H_2SO_4 = NaHSO_4 + HCl$. Or, $2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl$. &c. &c. *d.* HYPO-SULPHUROUS ACID $\mathbf{H_2S_2H_2O_4}$; not isolated. Salts called HYPO-SULPHITES. SODIUM HYPO-SULPHITE $Na_2S_2H_2O_4$, $4H_2O$, is much used in photography, as it dissolves silver-salts, which are insoluble in mere water. Thus: $AgCl + Na_2S_2H_2O_4 = NaCl + NaAgS_2H_2O_4$. Hyposulphites are made by digesting solutions of sulphites with flowers of sulphur; they are immediately decomposed by acids into WATER, SULPHUR, and SULPHUROUS ANHYDRIDE, $2\ HCl + Na_2S_2H_2O_4 = 2H_2O + 2NaCl + S + SO_2$. [*e.* DI-THIONIC ACID. $\mathbf{H_2S_2O_6}$. All dithionates are soluble in water. *Prep.* $MnO_2 + 2SO_2 = MnS_2O_6$. At the same time a little $MnSO_4$ is formed. By barium hydrate BaH_2O_2, BARIUM HYPO-SULPHATE BaS_2O_6 is obtained and MANGANOUS HYDRATE MnH_2O_2 precipitated. Then: $BaS_2O_6 + H_2SO_4 = BaSO_4 + \mathbf{H_2S_2O_6}$. TRI-THIONIC ACID $\mathbf{H_2S_3O_6}$, in prisms. Decomposes spontaneously into S, SO_2 and H_2SO_3. *f.* TETRATHIONIC ACID $\mathbf{H_2S_4O_6}$, decomposes by heat like trithionic acid. *g.* PENTATHIONIC ACID $\mathbf{H_2S_5O_6}$. Most unstable.] 3. **S with C.** CARBONIC SULPHIDE $\mathbf{CS_2} = 76$. A volatile, colourless liquid of sp. gr. 1.272 at 15°.5 C. Acrid, pungent taste, with the odour of cabbage-water. Insoluble in water, soluble in ethylic alcohol and ether. Inflammable in air to CO_2 and SO_2. A great solvent of sulphur, phosphorus, essential oils, &c. SULPHO-CARBONIC ACID $\mathbf{H_2CO_3}$. SULPHO-CARBONATES. *Prep.* of $\mathbf{CS_2}$. By passing S in vapour over red-hot charcoal.

[VI. Selenium Se = 79.5. $Se_2 = 159$.

6. SELENIUM **Se = 79.5.** $\mathbf{Se_2 = 159}$. Selenium is a dyad element, never found native, and with the greatest analogy to sulphur. A brittle solid, with vitreous fracture and lustre, of brown colour, but red in transmitted light. Insoluble in water; sp. gr. 4.79. It melts at 100° C., and boils at 343° C. Sp. gr. of its vapour at 1420° C. 5.68. In sulphuric acid selenium is soluble. Like sulphur, it has several allotropic modifications. **Compounds. Se with H.** HYDROGEN SELENIDE $\mathbf{H_2Se} = 81.5$. "Hydroselenic acid." Colourless, inflammable gas, of sp. gr. 40.75, compared with H, 11.19 litres, weigh 40.75 grammes.

SELENIDES. *Prep.* $FeSe + 2HCl = FeCl_2 + H_2Se$. **Se with O.** *a.* SELENIC OXIDE **SeO** = 95.5. A gas, with an odour as of horse-radish. *b.* Selenious anhydride SeO_2 = 111.5. White deliquescent mass; sublimes below redness. SELENOUS ACID, H_2SeO_3, is di-basic. SELENITES; alkaline are soluble. *Prep.* By burning **Se** in O_2, or oxydizing **Se** by HNO_3. *c.* SELENIC ACID H_2SeO_4. Isomorphous with sulphuric acid. By heat into water, oxygen, and selenious anhydride. Di-basic. SELENATES. *Prep.* Fusing Se with KNO_3; solution and precipitation as $PbSeO_4$ and decomposing $PbSeO_4$ by H_2S. $PbSeO_4 + H_2S = PbS + H_2SeO_4$.]

[VII. Tellurium Te = 129. Te_2 = 258.

7. TELLURIUM **Te = 129.** Molecular weight Te_2 = 258. Rarely native in Hungary. Chiefly as Ag, Au, Cu, Bi, and Pb tellurides. Metalline element, of tin-white lustre, closely allied to S and Se: like these elements, a dyad. Sp. gr. 6.65: the vapour at 1390° C. 9.0. Fuses at about 495° C. Burns, when heated in O, with blue flame edged with green to: TELLUROUS ANHYDRIDE TeO_2. Soluble in H_2SO_4. **Compounds. Te with H.** HYDROGEN TELLURIDE H_2Te = 131. Two vols. A gas with the odour of H_2S; soluble in H_2O. Alkaline TELLURIDES soluble. *Prep.* From ZINC TELLURIDE ZnTe, by HYDROGEN CHLORIDE HCl. $ZnTe + 2HCl = ZnCl_2 + H_2Te$. **Te with O.** 1. TELLUROUS ANHYDRIDE TeO_2, in octohedral crystals, fusible at a red heat. TELLUROUS ACID H_2TeO_3. Di-basic. TELLURITES. *Prep.* of TeO_2. *a.* By burning **Te** in O_2; *b.* by oxydizing Te with HNO_3. 2. TELLURIC ACID H_2TeO_4. In six-sided, striated prisms. Feeble acid. Di-basic. TELLURATES. *Prep.* of a TELLURATE. By fusing Te or TeO_2 with KNO_3.]

VIII. Chlorine Cl = 35.5. Cl_2 = 71.

8. CHLORINE **Cl = 35.5.** Molecular weight Cl_2 = 71. Not free in nature; chiefly as NaCl, KCl, $CaCl_2$, and $MgCl_2$ in sea water. Monad element. Discovered by Scheele in 1774. A yellowish-green gas, uninflammable, irrespirable, suffocating (antidotes NH_3 and ethylic alcohol C_2H_5HO). Its name from χλωρὸς, yellowish-green. 2.37 vols. soluble in one vol. of water at 15° C.; aqua chlorata. Supports combustion of many metals, and of compounds containing H. Under 4 atmospheres at 15° C., becomes a yellow liquid of sp. gr. 1·33. Hydrate of chlorine $Cl,5H_2O$, which crystallizes at 0°C. Chlorine bleaches and disinfects; the latter, chiefly because of the H contained in most poisonous gases. Decomposes even H_2O in the sunlight: hence an oxydizing agent. Thus: $Cl_2 + SO_2 + 2H_2O = H_2SO_4 + 2HCl$. 11.19 litres of chlorine gas weigh 35.5 grammes.

Sp. gr. 35.5 as compared with H. Salts called CHLORIDES, all of which are soluble in water, except SILVER CHLORIDE AgCl and MERCUROUS CHLORIDE Hg_2Cl_2; LEAD CHLORIDE $PbCl_2$, with difficulty. *Prep.* of **Cl**$_2$. 1. From MANGANESE PEROXIDE MnO_2 and HYDROGEN CHLORIDE HCl; MANGANOUS CHLORIDE $MnCl_2$, remains: $MnO_2 + 4HCl = MnCl_2 + 2H_2O + \mathbf{Cl_2}$. 2. From SODIUM CHLORIDE NaCl, MANGANESE PEROXIDE MnO_2 and SULPHURIC ACID H_2SO_4; SODIUM and MANGANOUS SULPHATES remain in the retort. $2NaCl + MnO_2 + 2H_2SO_4 = Na_2SO_4 + MnSO_4 + 2H_2O + \mathbf{Cl_2}$. **Compounds. Cl with H.** HYDROGEN CHLORIDE or HYDROCHLORIC ACID HCl = 36.5. 2 vols. Colourless, pungent, incombustible gas. 11.19 litres weigh 18.25 grammes. 18¼ times heavier than H. Very acid properties. Water at 0° C. absorbs 500 times its volume of the gas. Saturated solution at 4°.5 C. has a sp. gr. of 1.21, and contains 43 per cent. of the gas: cannot be distilled as such without loss of HCl. The pure acid solution of the laboratory has a sp. gr. of 1.11 at 15°.5 C., and may be distilled unchanged at 111°.7 C. Common MURIATIC ACID is also a solution of HCl, containing ferric chloride and sulphuric acid. *Prep.* of **HCl**. 1. By the union of **H** and **Cl**, equal volumes, in the sunlight or by heat. $Cl_2 + H_2 = 2\mathbf{HCl}$. 2. From SODIUM CHLORIDE and SULPHURIC ACID: $2NaCl + H_2SO_4 = Na_2SO_4 + 2\mathbf{HCl}$. ACTION OF **HCl** UPON NH_3. $\mathbf{HCl} + NH_3 = \mathbf{NH_4Cl}$. Hydrogen chloride fumes with NH_3 in the formation of AMMONIUM CHLORIDE NH_4Cl. ACTION OF **HCl** UPON METALS. Upon *monads:* $2\mathbf{HCl} + K_2 = H_2 + 2\mathbf{KCl}$. Upon *dyads:* $2\mathbf{HCl} + Zn = H_2 + ZnCl_2$. ACTION OF **HCl** UPON OXIDES. Upon *monad* oxides: $K_2O + 2\mathbf{HCl} = \mathbf{H_2O} + 2KCl$. Upon *dyad* oxides: $ZnO + \mathbf{2HCl} = \mathbf{H_2O} + ZnCl_2$. Upon *triad* oxides: $Fe_2O_3 + \mathbf{6HCl} = 3H_2O + Fe_2Cl_6$. Upon *tetrad* oxides: $SnO_2 + \mathbf{4HCl} = 2\mathbf{H_2O} + SnCl_4$. ACTION OF **HCl** UPON HYDRATES. $KHO + \mathbf{HCl} = \mathbf{H_2O} + KCl$. $ZnH_2O_2 + \mathbf{2HCl} = 2\mathbf{H_2O} + ZnCl_2$. $Fe_2H_6O_6 + \mathbf{6HCl} = 6H_2O + Fe_2Cl_6$. NITRO-MURIATIC ACID or AQUA REGIA is a mixture of **HCl** with $\mathbf{HNO_3}$, a solvent of Au, Pt, &c.; CHLORIDES always formed. $6HCl + 2HNO_3 = 2(NOCl_2) + 4H_2O + \mathbf{Cl_2}$ free. [NITRIC OXY-CHLORIDE $\mathbf{NOCl_2}$, a dense, red, fuming liquid below −7° C., or generally a gas of a deep lemon-yellow colour. By water decomposed into NO_2 and HCl: $\mathbf{NOCl_2} + H_2O = NO_2 + 2HCl$. NITROUS OXY-CHLORIDE **NOCl**, also formed in the process of action of HCl upon HNO_3.] **Cl with O.** 1. HYPOCHLOROUS ACID **HClO** = 52.5. Formed by the action of H_2O upon HYPOCHLOROUS ANHYDRIDE Cl_2O. $\mathbf{Cl_2O} + \mathbf{H_2O} = 2\mathbf{HClO}$. One vol. of water absorbs 200 vols. of the anhydride. HYPOCHLORITES. Great bleaching agents. By gentle heat: $3KClO = 2KCl + KClO_3$. *Prep.* of **HClO**. From calcium oxy-chloride by distillation with H_2SO_4 insufficient to decompose the whole calcium salt. $2CaOCl_2 + H_2SO_4 = CaSO_4 + CaCl_2 + 2\mathbf{HClO}$.

[HYPOCHLOROUS ANHYDRIDE $\mathbf{Cl_2O}$ = 87. 2 vols. A gas condensible to a red liquid at −18° C., boils at 20° C. *Prep.* of $\mathbf{Cl_2O}$. $2HgO + 2Cl_2 = HgO,HgCl_2 + \mathbf{Cl_2O}$. 2. CHLOROUS ACID $\mathbf{HClO_2}$. A liquid possessed of great bleaching properties. CHLORITES. Water absorbs 6 vols. of CHLOROUS ANHYDRIDE Cl_2O_3, with which it forms chlorous acid. $Cl_2O_3 + H_2O = 2\mathbf{HClO_2}$. CHLOROUS ANHYDRIDE $\mathbf{Cl_2O_3}$ = 119. A gas of deep yellowish-green colour. Decomposes at 55° C. Dangerous properties. Sp. gr. 39.66, as compared with H. The molecule occupies 3 vols. *Prep.* $2HNO_2 + 2KClO_3 = 2KNO_3 + H_2O + \mathbf{Cl_2O_3}$.] 3. CHLORIC ACID $\mathbf{HClO_3}$ = 84.5. A syrupy, powerfully acid liquid: decomposes above 38° C. $8HClO_3 = 2H_2O + 3O_2 + 2Cl_2 + 4HClO_4$. Salts called CHLORATES, all of which soluble in water. $KClO_3$ the chief source of oxygen. $2KClO_3$ by heat $= 2KCl + 3O_2$. *Prep.* of $\mathbf{HClO_3}$. $2KClO_3 + 2HF,SiF_4 = 2KF,SiF_4 + 2\mathbf{HClO_3}$. N.B.—When Cl_2 is absorbed by potassium hydrate, potassium chloride and chlorate are formed: $6KHO + 3Cl_2 = 3H_2O + 5KCl + KClO_3$. [4. CHLORINE PEROXIDE $\mathbf{ClO_2}$ = 67.5. Gas of deep yellow colour, less irritating than Cl. Explodes at 63° C. At −20° C., a red liquid. *Prep.* of $\mathbf{ClO_2}$. $3KClO_3 + 2H_2SO_4 = 2KHSO_4 + H_2O + KClO_4 + 2\mathbf{ClO_2}$. Water dissolves 20 vols., but the solution has no acid properties. 5. PERCHLORIC ACID $\mathbf{HClO_4}$ = 100.5. An oil-like liquid, which forms with water a crystalline hydrate. Distils at 110 C. Salts, PERCHLORATES. *Prep.* of $\mathbf{HClO_4}$. $8KClO_3 + 4H_2SO_4 = 4K_2SO_4 + 2H_2O + 3O_2 + 2Cl_2 + 4\mathbf{HClO_4}$. POTASSIUM PERCHLORATE $KClO_4$ can be obtained in making O from $KClO_3$, if the process be broken off when the fluid mass begins to be pasty: $2KClO_3 = KCl + O_2 + KClO_4$.] **Cl with N.** [CHLORIDE OF NITROGEN $NCl_3,NHCl_2$? Liquid of sp. gr. 1.653. Highly explosive. Spontaneously below 100° C. *Prep.* by the action of Cl_2 upon NH_4Cl in solution.] **Cl with C.** [CARBONIC CHLORIDE $\mathbf{CCl_4}$ = 154. Colourless liquid; boils at 78° C. ETHYLENE CHLORIDE $\mathbf{C_2Cl_4}$ = 166. Volatile, colourless liquid. Sp. gr. 1.619. Boils at 120° C. From the vapour of C_2Cl_6 at a red-heat. CARBONIC SESQUI-CHLORIDE $\mathbf{C_2Cl_6}$ = 237. White, crystalline, aromatic substance; melts at 160° C. CARBONOUS CHLORIDE $\mathbf{C_2Cl_2}$ = 95. CARBONIC OXY-CHLORIDE $\mathbf{COCl_2}$ = 99. Gas, colourless, suffocating. By water, decomposed: $COCl_2 + H_2O = 2HCl + CO_2$. *Prep.* from equal vols. of CO_2 and Cl_2 in the sunshine.] **Cl with S.** [SULPHUROUS CHLORIDE $\mathbf{S_2Cl_2}$ = 135. Yellow, volatile liquid. SULPHURIC CHLORIDE SCl_2 = 103. Deep-red fluid.]

IX. Bromine Br = 80. Br_2 = 160.

9. BROMINE **Br = 80.** Molecular weight $\mathbf{Br_2 = 160}$. Never native. Monad element, closely allied to chlorine. In sea

water as $MgBr_2$. Also in springs at Kreuznach. **Br** is a thin red fluid, irritating, poisonous. Its name from *βρώμος*, a bad smell. Sp. gr. of the liquid at 0° C., 3.187. Boils at 63° C. Solid below −20° C. Little soluble in water. Its hydrate $Br,5H_2O$. Very soluble in alcohol, and still more so in ether. 11.19 litres of the vapour weigh 80 grammes. BROMIDES are the salts of bromine. Resemble chlorides. Decomposed by HNO_3. *Prep.* of Br_2. $MgBr_2 + Cl_2 = MgCl_2 + Br_2$. Also: $2KBr + MnO_2 + 2H_2SO_4 = K_2SO_4 + MnSO_4 + 2H_2O + Br_2$. **Compounds. Br with H.** [HYDROBROMIC ACID **HBr** = **81**. 2 vols. A gas, 11.19 litres of which weigh 40.5 grammes. Its solution, $HBr,5H_2O$, is a colourless, fuming liquid of sp. gr. 1.486, contains 47 per cent. of **HBr**; boils at 126° C., and distils. Oxydizes *in part* on exposure to the air, with separation of Br_2. Solution decomposed by Cl_2. Forms BROMIDES and water, by contact with metallic oxides and hydrates. $2HBr + Cl_2 = 2HCl + Br_2$. *Prep.* of **HBr**. 1. $3KBr + H_3PO_4 = K_3PO_4 + 3HBr$. 2. $2Br_2 + 2H_2S = S_2 + 4HBr$. 3. $PBr_3 + 3H_2O = H_3PHO_3 + 3HBr$.] **Br with O.** [1. HYPOBROMOUS ANHYDRIDE Br_2O. $2Br_2 + HgO = HgBr_2 + Br_2O$. By water into HYPOBROMOUS ACID **HBrO**. $H_2O + Br_2O = 2HBrO$. 2. BROMIC ACID $HBrO_3$ = **129**. More stable than $HClO_3$. *Prep.* $Ba2BrO_3 + H_2SO_4 = BaSO_4 + 2HBrO_3$. The action of Br_2 upon KHO, similar to that of Cl_2. $6KHO + 3Br_2 = 3H_2O + 5KBr + KBrO_3$. POTASSIUM BROMATE $KBrO_3$ is separated by crystallization from water. $2KBrO_3$ by heat $= 3O_2 + 2KBr$. 3. PERBROMIC ACID $HBrO_4$. From $HClO_4$ by Br_2. $2HClO_4 + Br_2 = Cl_2 + 2HBrO_4$.] **Br and N.** [BROMIDE OF NITROGEN NBr_3. An oily, detonating fluid.]

X. Iodine I = 127. I_2 = 254.

10. IODINE = **I.127**. Molecular weight I_2 = **254**. Never native. Monad element, like Cl and Br. Discovered by Courtois in 1811 in the ashes of seaweed. Occurs as NaI in sea-water; also in various springs. A solid, of lead-grey, metallic lustre, resembling plumbago. Fuses at 107° C. Boils at 180° C. Sp. gr. of I 4.95. Little soluble in water; very soluble in alcohol (tincture of iodine) and ether. 11.19 litres of its vapour weigh 127 grammes. The vapour is violet-coloured, whence the name, from *ἰώδης*. Salts called IODIDES. SILVER IODIDE **AgI** is yellow, insoluble in H_2O, in HNO_3, and in NH_3. MERCURIC IODIDE HgI_2, is scarlet, and insoluble in H_2O. MERCUROUS IODIDE Hg_2I_2 is green, and insoluble. LEAD IODIDE PbI_2 is yellow and insoluble in water. Chief test for free iodine is starch, which forms purple iodide of starch. *Prep.* of I_2. From the ash of seaweed, after removal of various salts: $2NaI + MnO_2 +$

$2H_2SO_4 = Na_2SO_4 + MnSO_4 + 2H_2O + I_2$. **Compounds. I with H.** [HYDRIODIC ACID **HI** = 128. Colourless gas, irritating, fuming. Very soluble in water. 11.19 litres weigh 64 grammes. Condensible to a fluid below −55° C. Slowly and completely decomposed in air. Also by Cl and Br. *Prep.* 1. $2H_2S + 2I_2 = S_2 + 4HI$. 2. $PI_3 + 3H_2O = H_2PHO_3 + 3HI$. 3. $8KI + P_4 + 10I_2 + 16H_2O = 4K_2HPO_4 + 28HI$. 4. $3KI + H_3PO_4 = K_3PO_4 + 3HI$.] **I with O.** [1. IODIC ACID HIO_3 = 176. In crystals. Salts called IODATES. *Prep.* 1. By oxydizing I with HNO_3. 2. $Ba2IO_3 + H_2SO_4 = BaSO_4 + 2HIO_3$. 3. $I_2 + 6H_2O + 5Cl_2 = 10HCl + 2HIO_3$. By carefully heating HIO_3 to 170° C., we obtain IODIC ANHYDRIDE I_2O_5. *Prep.* $2HIO_3 = H_2O + I_2O_5$. 2. PER-IODIC ACID HIO_4 = 192. In crystals. *Prep.* 1. $2HClO_4 + I_2 = Cl_2 + 2HIO_4$. 2. $NaIO_3 + 2NaHO + Cl_2 = 2NaCl + H_2O + NaIO_4$. Then: $2NaIO_4 + Pb2C_2H_3O_2 = 2NaC_2H_3O_2 + Pb2IO_4$. Again: $Pb2IO_4 + H_2SO_4 = PbSO_4 + 2HIO_4$. PER-IODIC ANHYDRIDE I_2O_7 results when HIO_4 is heated to 160° C. $2HIO_4 = H_2O + I_2O_7$.] **I with N.** [IODIDE OF NITROGEN NI_3 and NHI_2. A black, detonating powder. *Prep.* $3NH_3 + 2I_2 = 2NH_4I + NHI_2$.]

XI. Fluorine F = 19. F_2 = 38?

11. FLUORINE **F = 19.** Molecular weight probably F_2 = 38. Monad element. In combination with calcium, as CALCIUM FLUORIDE CaF_2; also in kryolite and apatite. Probably a gas; with most powerful affinities. Salts called FLUORIDES. **Compounds. F with H.** HYDROGEN FLUORIDE OR HYDRO-FLUORIC ACID **HF** = 20. Colourless gas, very corrosive. 11·19 litres weigh 10 grammes. The hydrate $HF,2H_2O$ is a fuming volatile liquid of sp. gr. 1·15; boils at 120° C. Etches glass, by uniting with the SILICON, **Si**, of the combined SILICA SiO_2; SILICON FLUORIDE SiF_4 escapes as a gas, whilst WATER H_2O, is simultaneously formed: $4HF + SiO_2 = 2H_2O + SiF_4$. *Prep.* of **HF**. $CaF_2 + H_2SO_4 = CaSO_4 + 2HF$. Distilled from leaden retorts. The acid must be preserved in vessels of silver, lead, platinum, or gutta percha.

XII. Phosphorus P = 31. P_4 = 124 = 2 vols.

12. PHOSPHORUS **P = 31.** Molecular weight, P_4 = 124. A triad element; never found native. A constituent of the bones, of vertebrata, of urine; in brains and nerves, in primitive and volcanic rocks. Discovered by Brandt in 1669. Called PHOSPHORUS from its luminosity in air, from φῶς light, and φορὸς bearer. Allotropic: di-morphous. 5 varieties. P^{α}. A colourless, wax-like solid, of sp. gr. 1.83; melts at 44° C; boils at 290° C. Insoluble in water; soluble in CS_2, PCl_3, and in S_2Cl_2, slightly soluble in ether. Crystallizes in rhombic dodecahedra.

Very poisonous. Inflammable at 46° C.; burns to PHOSPHOROUS P_2O_3, or PHOSPHORIC ANHYDRIDE P_2O_5, depending upon the quantity of O present. 11.19 litres of phosphorus vapour weigh 62 grammes, viz., TWICE the WEIGHT of the ATOM. Used in matches and medicinally. P^β. Under water, exposed to light, common changes into P^β. It is white and more dangerous to handle; sp. gr. 1·515. At 50° C. changes into common. P^γ is black, obtained by frequent and sudden cooling of melted phosphorus. By fusion and slow cooling, returns to common P^α. P^δ viscous, like S^γ. By heating P^α to 260° C, and sudden cooling. P^ϵ Red powder of sp. gr. 2.14. Insoluble in all media. Not poisonous. In Bryant and May's matches. Returns to P^α at a temperature of 260° C. *Prep.* by heating common P^α between 235°—250° C., in tubes from which the air has been expelled, for 30-40 hours. *Prep.* of common P^α. 1. By conversion of CALCIUM ORTHOPHOSPHATE $Ca_3 2PO_4$ into CALCIUM HYDROGEN ORTHOPHOSPHATE $CaH_4 2PO_4$ by means of sulphuric acid H_2SO_4. $Ca_3 2PO_4 + 2H_2SO_4 = 2CaSO_4 + CaH_4 2PO_4$. 2. By heating the latter salt to bright redness with charcoal, and collecting the P_4 under water. $3CaH_4 2PO_4 + 16C = Ca_3 2PO_4 + 6H_2 + 16CO + P_4$. **Compounds. P with H.** 1. PHOSPHORUS HYDRIDE $PH_3 = 34$. 2 vols. Is the common phosphoretted hydrogen. A colourless gas, of offensive odour as of putrid fish; insoluble in water. 11.19 litres weigh 17 grammes. Inflamed, it burns to H_2O and P_2O_5; 2 vols. of the gas require 4 vols. of O for full combustion. It is the analogue of nitrogen hydride, or ammonia NH_3. [Unites directly with I to PHOSPHOROUS IODIDE PI_3 and HYDRIODIC ACID HI; and with PHOSPH-AMMONIUM to PHOSPH-AMMONIUM IODIDE PH_4I. $PH_3 + HI = PH_4I$. PH_3 does not unite with other acids to form salts. Reduces silver salts: $PH_3 + 4H_2O + 8AgNO_3 = 4Ag_2 + 8HNO_3 + H_3PO_4$. With CUPRIC SULPHATE forms cupric phosphide: $2PH_3 + 3CuSO_4 = 3H_2SO_4 + Cu_3P_2$.] *Prep.* of PH_3. 1. By heating PHOSPHOROUS ACID H_2PHO_3. $4H_2PHO_3 = 3H_3PO_4 + PH_3$. 2. By heating HYPO-PHOSPHOROUS ACID HPH_2O_2. $2HPH_2O_2 = H_3PO_4 + PH_3$. 3. By boiling P_4 with liquor potassæ. $P_4 + 3KHO + 3H_2O = 3KPH_2O_2 + PH_3$. [N.B. In the latter process, liquid phosphorus hydride is formed, which renders it spontaneously inflammable in air. 2. DI-PHOSPHORUS TETRA-HYDRIDE H_4P_2 is liquid, and spontaneously inflammable. TETRA-PHOSPHORUS DI-HYDRIDE H_2P_4, is solid. *Prep.* By passing H_4P_2 into HCl. $5H_4P_2 = 6PH_3 + H_2P_4$.] **P with Cl.** [1. PHOSPHOROUS CHLORIDE $PCl_3 = 137.5$. Colourless, volatile liquid, of sp. gr. 1.45; boils at 78° C. Decomposed by water into HCl and PHOSPHOROUS ACID H_2PHO_3. Thus: $PCl_3 + 3H_2O = 3HCl + H_2PHO_3$. Solvent of P_4 and S_2. *Prep.* By the action of Cl upon excess of P. 2. PHOS-

PHORIC CHLORIDE $\mathbf{PCl_5}$ = 208·5. Solid, crystalline body, volatile below 100° C. By water into HCl and ORTHO-PHOSPHORIC ACID H_3PO_4. $\mathbf{PCl_5} + 4H_2O = 5HCl + \mathbf{H_3PO_4}$. *Prep.* By passing Cl_2 into $PCl_3 = \mathbf{PCl_5}$. PHOSPHORIC OXY-CHLORIDE $\mathbf{POCl_3}$ = 153·5. A liquid of sp. gr. 1.7, boils at 110° C. *Prep.* 1. By the action of one molecule of water upon phosphoric chloride: $PCl_5 + H_2O = 2HCl + \mathbf{POCl_3}$. 2. By the action of PCl_5 upon ETHYLIC ALCOHOL. $PCl_5 + C_2H_5HO = CH_3,CH_2Cl + HCl + \mathbf{POCl_3}$. PHOSPHORIC SULPHO-CHLORIDE $\mathbf{PSCl_3}$ = 169.5. Liquid; boils at 128° C. *Prep.* By H_2S upon $PCl_5 = 2HCl + \mathbf{PSCl_3}$.] **P with Br.** [$\mathbf{PBr_3}$ and $\mathbf{PBr_5}$.] **P with I.** [$\mathbf{PI_3}$ and $\mathbf{P_2I_4}$.] **P with O.** 1. PHOSPHORIC ANHYDRIDE $\mathbf{P_2O_5}$ = 142. Deliquescent, snow-white solid. By water into METAPHOSPHORIC ACID $\mathbf{HPO_3}$. $P_2O_5 + H_2O = 2HPO_3$. *Prep.* By burning P in O. $P_4 + 5O_2 = 2\mathbf{P_2O_5}$. 2. PHOSPHOROUS ANHYDRIDE $\mathbf{P_2O_3}$ = 110. Snow-white powder, with greedy affinity for O_2 and for water. By contact with water into: PHOSPHOROUS ACID $\mathbf{H_2PHO_3}$. Thus: $P_2O_3 + 3H_2O = 2H_2PHO_3$. *Prep.* of P_2O_3. By the slow and incomplete oxydation of P. 3. PHOSPHORIC OXIDE $\mathbf{P_4O}$ = 140. A red powder, always formed in the incomplete combustion of P_4. THE ACIDS OF PHOSPHORUS, five in number; besides the hexa-basic and dodeca-basic phosphoric acids. 1. HYPOPHOSPHOROUS ACID $\mathbf{HPH_2O_2}$ = 66. A feeble acid: can be obtained of syrupy consistence. Monobasic. Hypo-phosphites. By heat into PH_3 and H_3PO_4. *See* $\mathbf{PH_3}$. *Prep.* From $Ba2PH_2O_2 + H_2SO_4 = BaSO_4 + 2\mathbf{HPH_2O_2}$. 2. PHOSPHOROUS ACID $\mathbf{H_2PHO_3}$ = 82. In deliquescent, rectangular prisms. Di-basic. Phosphites. At a red-heat into PH_3 and H_3PO_4. *See* PH_3. *Prep.* Most readily from phosphorous chloride by water: $PCl_3 + 3H_2O = 3HCl + \mathbf{H_2PHO_3}$. 3. PHOSPHORIC ACIDS. META-PHOSPHORIC ACID $\mathbf{HPO_3}$ = 80. The so-called "glacial" phosphoric acid. Very soluble in water and precipitates albumen. Mono-basic. META-PHOSPHATES; those of Ag and Ba white, and soluble in HNO_3. *Prep.* By heating ORTHO-PHOSPHORIC, H_3PO_4, or PYRO-PHOSPHORIC ACID $H_4P_2O_7$, to redness. Thus: $H_3PO_4 = H_2O + \mathbf{HPO_3}$. Or: $H_4P_2O_7 = H_2O + 2\mathbf{HPO_3}$. 4. PYRO-PHOSPHORIC ACID $\mathbf{H_4P_2O_7}$ = 178. In crystals, by evaporation in vacuo. Tetra-basic. PYRO-PHOSPHATES: Ag and Ba pyro-phosphates, white and soluble in HNO_3. *Prep.* By heating ORTHO-PHOSPHORIC ACID H_3PO_4 to 213°. Thus: $2H_3PO_4 = H_2O + \mathbf{H_4P_2O_7}$. From LEAD PYRO-PHOSPHATE $Pb_2P_2O_7$ by $2H_2S = 2PbS + \mathbf{H_4P_2O_7}$. (SODIUM PYRO-PHOSPHATE $Na_4P_2O_7$ is obtained by heating DI-SODIUM HYDROGEN-ORTHO-PHOSPHATE Na_2HPO_4 to low redness: $2Na_2HPO_4 = H_2O + Na_4P_2O_7$. LEAD PYRO-PHOSPHATE $Pb_2P_2O_7$, is obtained by adding LEAD ACETATE $Pb2C_2H_3O_2$ to a solution of sodium pyro-phosphate. Thus: $2Pb2C_2H_3O_2 + Na_4P_2O_7 = 4NaC_2H_3O_2 + Pb_2P_2O_7$.) 5. ORTHO-PHOSPHORIC ACID $\mathbf{H_3PO_4}$ =

98. Is normal "phosphoric acid." When a phosphate is spoken of, without any prefix, an ortho-phosphate is meant. Ordinary "bone phosphate" is CALCIUM ORTHO-PHOSPHATE $Ca_3 2PO_4$; from it all phosphates are made. $\mathbf{H_3PO_4}$ can be obtained in crystals. Tri-basic. ORTHO-PHOSPHATES. SILVER ORTHO-PHOSPHATE Ag_3PO_4, is yellow and soluble in HNO_3. BARIUM ORTHO-PHOSPHATE $Ba_3 2PO_4$ is white and soluble in HNO_3. MAGNESIUM ORTHO-PHOSPHATE $MgHPO_4$ is white, granular, crystalline, nearly insoluble in water. AMMONIUM MAGNESIUM ORTHO-PHOSPHATE $NH_4MgPO_4,6H_2O$, or "triple phosphate," is changed by heat into MAGNESIUM PYRO-PHOSPHATE $Mg_2P_2O_7$, 100 parts of which contain 63.96 per cent. of P_2O_5. *Prep.* of $\mathbf{H_3PO_4}$. *a.* By boiling P_2O_5 or HPO_3 or $H_4P_2O_7$ with water for some time. *b.* By oxydizing P with HNO_3. *c.* In an impure state from calcium ortho-phosphate by excess of H_2SO_4.

XIII. Arsenicum As = 75. As_4 = 300.

13. ARSENICUM **As = 75.** Molecular weight $\mathbf{As_4 = 300}$ = 2 vols. Rarely native. A triad element like phosphorus. Brilliant, steel-grey, crystalline solid. Sp. gr. 5.6 to 5.95; volatilizes without fusion at 180° C. 11.19 litres of the vapour weigh 150 grammes. Tarnishes in air, and burns with bluish-white flame to ARSENIOUS ANHYDRIDE As_2O_3. Inflames in Cl. By HNO_3 into ARSENIC ACID H_3AsO_4. Alloys with Pb and other metals. Found principally as MISPICKEL FeAsS; TIN-WHITE COBALT $CoAs_2$; COBALT-GLANCE CoSAs; NICKEL-GLANCE NiSAs; KUPFER-NICKEL NiAs; ARSENICAL NICKEL $NiAs_2$. *Prep.* of $\mathbf{As_4}$. $2As_2O_3 + 3C = 3CO_2 + As_4$. N.B. Arsenicum soluble in $CaOCl_2$. **Compounds.—As with H.** ARSENICUM HYDRIDE $\mathbf{AsH_3 = 78}$. 2 vols. Colourless gas, with garlic odour; highly poisonous. Known as ARSENIETTED HYDROGEN. At − 40°C., a limpid liquid; burns with bluish-white flame to H_2O and ARSENIOUS ANHYDRIDE As_2O_3. $2AsH_3 + 3O_2 = 3H_2O + As_2O_3$. Reduces silver nitrate; absorbed by cupric sulphate. Heated below redness in absence of air, deposits steel-grey crust of As, and H separates. Burnt in insufficient air: $4AsH_3 + 3O_2 = 6H_2O + As_4$. *Prep.* of $\mathbf{AsH_3}$. *a.* From $Zn_3As_2 + 3H_2SO_4 = 3ZnSO_4 + 2AsH_3$. *b.* $H_3AsO_3 + 3H_2 = 3H_2O + AsH_3$. **As with Cl.** ARSENIOUS CHLORIDE $\mathbf{AsCl_3} = 181.5$; 2 vols. Colourless liquid, of sp. gr. 2.2. Boils at 132°C. By water, into HCl and H_3AsO_3. $AsCl_3 + 3H_2O = 3HCl + H_3AsO_3$. *Prep.* of $\mathbf{AsCl_3}$. *a.* Burning As in Cl. *b.* By distilling As_4 with mercuric chloride: $As_4 + 12HgCl_2 = 6Hg_2Cl_2 + 4AsCl_3$. [**As Br_3. AsI_3** brick-red powder. **AsF_3.**] **As with O.** ARSENIOUS ANHYDRIDE $\mathbf{As_2O_3} = 198 = 1$ vol. A rare mineral. In 2 modifications: vitreous and crystalline. When recently sublimed,

amorphous, vitreous, of sp. gr. 3.738: by keeping, opaque, crystalline, porcelain-like, sp. gr. 3.699. Vitreous the more soluble. Water at 100°C. dissolves between 11 and 12 per cent. More soluble in HCl. The powder heavy, difficult to moisten; softens at 193°.3C. and sublimes in octohedra. Poisonous: antidotes, magnesia and precipitated ferric hydrate. ARSENIOUS ACID $\mathbf{H_3AsO_3 = 126}$. Tri-basic; salts ARSENITES. *Prep.* of $\mathbf{As_2O_3}$. By roasting arsenical ores or by burning As_2. ARGENTUM ARSENITE Ag_3AsO_3 is canary-yellow, soluble in HNO_3 and in NH_3. CUPRIC HYDROGEN ARSENITE $CuHAsO_3$, is Scheele's green, soluble in NH_3 and in HNO_3. ARSENIC ANHYDRIDE $\mathbf{As_2O_5} =$ 230. Obtained by strongly heating ARSENIC ACID $\mathbf{H_3AsO_4}$. $2H_3AsO_4 = 3H_2O + \mathbf{As_2O_5}$. ORTH-ARSENIC ACID $\mathbf{H_3AsO_4 = 142}$. In needles. Tri-basic. Salts: ORTH-ARSENATES, many of which are isomorphous with the ortho-phosphates. SILVER ORTH-ARSENATE Ag_3AsO_4, is liver-brown, soluble in NH_3 and in HNO_3. CUPRIC ORTH-ARSENATE $CuHAsO_4$ is blue and soluble in NH_3 and in HNO_3. MET-ARSENIC ACID $\mathbf{HAsO_3}$, and PYR-ARSENIC ACID $\mathbf{H_4As_2O_7}$, also exist. **As and S.** *a.* DI-ARSENICUM DI-SULPHIDE $\mathbf{As_2S_2 = 214}$. Is "realgar." Native, in ruby-red crystals of sp. gr. 3.5. Also prepared artificially: $4As_2O_3 + 7S_2 = 6SO_2 + 4\mathbf{As_2S_2}$. *b.* ARSENIOUS SULPHIDE $\mathbf{As_2S_3} = 246$. Called "orpiment" or "sulph-arsenious anhydride." Native. Yellow, solid, of sp. gr. 3.5. Soluble in NH_3, in KHO, in NH_4HS, and in NH_4HCO_3. *Prep.* $3H_2S + 2AsCl_3 = 6HCl + \mathbf{As_2S_3}$. Dissolves in potassium hydrate. $\mathbf{As_2S_3} + 4KHO = H_2O + K_2HAsO_3 + K_2HAsS_3$. *c.* ARSENIC SULPHIDE $\mathbf{As_2S_5} =$ 310. Yellow substance obtained by the fusion of S_2 with As_2S_3. Also called "sulph-arsenic anhydride."

XIV. Stibium or Antimony Sb = 122. $Sb_4 = 488$.

14. STIBIUM $\mathbf{Sb = 122}$. Molecular weight $\mathbf{Sb_4} = 488 = 2$ vols. A triad element, like phosphorus and arsenicum. White, lustrous metal; brittle, crystallizing in rhomboids. Sp. gr. 6.7. Melts at 621°C. Burns, when strongly heated, to ANTIMONOUS OXIDE Sb_2O_3. By strong HCl into $SbCl_3$. By HNO_3 into MET-ANTIMONIC ACID $HSbO_3$. Chief ore of antimony, ANTIMONOUS SULPHIDE Sb_2S_3. *Prep.* of **Sb**. *a.* $2Sb_2S_3 + 6Fe = 6FeS + \mathbf{Sb_4}$. *b.* $2Sb_2O_3 + 6C = 6CO + \mathbf{Sb_4}$. **Compounds.—Sb with H.** ANTIMONOUS HYDRIDE $\mathbf{SbH_3}$; or ANTIMONIETTED HYDROGEN; colourless gas, burning with greenish flame to H_2O and ANTIMONOUS OXIDE Sb_2O_3. Burnt with limited supply of O, into H_2O and Sb. Thus: $4\mathbf{SbH_3} + 3O_2 = 6H_2O + \mathbf{Sb_4}$. The Sb thus deposited is easily dissolved by $(NH_4)_2S$. Heated to redness, in absence of air, into Sb and H. *Prep.* of $\mathbf{SbH_3}$. *a.* From any compound in presence of nascent hydrogen: $\mathbf{SbCl_3} +$

$3H_2 = 3HCl + SbH_3$. *b.* $Zn_3Sb_2 + 6HCl = 3ZnCl_2 + 2SbH_3$. **Sb with Cl.** ANTIMONOUS CHLORIDE $SbCl_3 = 288.5 = 2$ vols. Deliquescent mass, fuses at 72° C., and boils at 223° C. Decomposed by H_2O into ANTIMONOUS OXY-CHLORIDE **SbOCl**. $SbCl_3 + H_2O = 2HCl + SbOCl$. *Prep.* of $SbCl_3$. *a.* By burning **Sb** in **Cl**. *b.* By dissolving Sb_2S_3 in HCl, and then distilling: $Sb_2S_3 + 6HCl = 3H_2S + 2SbCl_3$. *c.* By distilling ANTIMONOUS SULPHIDE Sb_2S_3 with MERCURIC CHLORIDE $HgCl_2$. Thus: $Sb_2S_3 + 3HgCl_2 = 3HgS + 2SbCl_3$. ANTIMONIC CHLORIDE $SbCl_5 = 299.5$. Colourless fluid, solid below 0°C. Volatile. By H_2O into 2HCl and ANTIMONIC OXY-CHLORIDE $SbOCl_3$. But, by excess of water, into ORTH-ANTIMONIC ACID H_3SbO_4. Thus: $SbCl_5 + 4H_2O = 5HCl + H_3SbO_4$. In the same manner, by H_2S, antimonous chloride is changed into ANTIMONIC SULPHO-CHLORIDE $SbSCl_3$. Thus: $SbCl_5 + H_2S = 2HCl + SbSCl_3$. *Prep.* of $SbCl_5$. *a.* By burning **Sb** in excess of **Cl**. *b.* From $SbCl_3 + Cl_2 = SbCl_5$. [$SbBr_3$ fuses at 90° C. and boils at 270°. $SbBr_3 + H_2O = 2HBr + SbOBr$. SbI_3. By water: $SbI_3 + H_2O = 2HI + SbOI$. SbF_3.] **Sb with O.** 1. ANTIMONOUS OXIDE $Sb_2O_3 = 292$. Native, as *white antimony ore*, in prisms. Grey-white powder, yellow on heating, soluble in HCl and in $H_2C_4H_4O_6$. Has basic properties. Burns in air into ANTIMONOUS-MONIC OXIDE Sb_2O_4 or Sb_2O_3,Sb_2O_5. *Prep.* of Sb_2O_3. *a.* By burning Sb in O. *b.* By pouring $SbCl_3$ into a boiling solution of sodium carbonate $2SbCl_3 + 3Na_2CO_3 = 6NaCl + 3CO_2 + Sb_2O_3$. *c.* From METANTIMONOUS ACID $HSbO_2$ at 100° C. $2HSbO_2 = H_2O + Sb_2O_3$. [2. METANTIMONOUS ACID $HSbO_2 = 155$. Forms METANTIMONITES. *Prep.* By pouring $SbCl_3$ into a *cold* solution of Na_2CO_3. $2SbCl_3 + 3Na_2CO_3 + H_2O = 6NaCl + 3CO_2 + 2HSbO_2$. 3. ANTIMONOUS-ANTIMONIC OXIDE $Sb_2O_4 = 308$. Native. Obtained by strongly heating Sb_2O_3 in the air. $2Sb_2O_3 + O_2 = 2Sb_2O_4$. Also: $2Sb_2O_5$ by strong heat $= O_2 + 2Sb_2O_4$.] 4. ANTIMONIC ANHYDRIDE $Sb_2O_5 = 324$. Pale, yellow powder. 3 ACIDS. Fused with potassium carbonate, forms POTASSIUM METANTIMONATE $KSbO_3$. Thus: $Sb_2O_5 + K_2CO_3 = CO_2 + 2KSbO_3$. ORTH-ANTIMONIC ACID H_3SbO_4. Little known. Formed (?) by the action of $4H_2O$ upon $SbCl_5 = 5HCl + H_3SbO_4$. METANTIMONIC ACID $HSbO_3$. By HNO_3 upon Sb. $8HNO_3 + Sb_4 = 2N_2O_3 + 4NO + 2H_2O + 4HSbO_3$. With $KHO = H_2O$ + POTASSIUM METANTIMONATE $KSbO_3$. PYR-ANTIMONIC ACID $H_4Sb_2O_7$; is the METANTIMONIC ACID of Frémy. It is tetra-basic, and corresponds with $H_4P_2O_7$ and $H_4As_2O_7$. From POTASSIUM DIHYDRIC PYR-ANTIMONATE and HCl. $K_2H_2Sb_2O_7 + 2HCl = 2KCl + H_4Sb_2O_7$ Solution of $K_2H_2Sb_2O_7$ employed as a test for sodium; $Na_2H_2Sb_2O_7,6H_2O$ is precipitated. **Sb and S.** ANTIMONOUS SULPHIDE $Sb_2S_3 = 340$. Native as stibnite or grey-antimony ore. Orange when precipitated; soluble in HCl and in NH_4HS; *not* in NH_4HCO_3 and

but little in NH_3. Employed in making H_2S. Thus: $Sb_2S_3 + 6HCl = 2SbCl_3 + 3H_2S$. Chiefly in making the metal. The mineral first roasted and changed partially into Sb_2O_3. Thus: $2Sb_2S_3 + 9O_2 = 6SO_2 + 2Sb_2O_3$. A portion of Sb_2S_3 remains unchanged, and therefore it is fused with sodium carbonate: $Sb_2S_3 + 3Na_2CO_3 = 3Na_2S + 3CO_2 + Sb_2O_3$. Lastly, Sb_2O_3 is reduced with charcoal: $2Sb_2O_3 + 6C = 6CO + Sb_4$. SULPH-ANTIMONITES. ANTIMONOUS OXY-DISULPHIDE Sb_2OS_2, native as "red-antimony." ANTIMONIC SULPHIDE $Sb_2S_5 = 404$. Or "sulphantimonic anhydride." Orange-red, soluble in alkaline sulphides. *Prep.* of Sb_2S_5. $2SbCl_5 + 5H_2S = 10HCl + Sb_2S_5$.

XV. Bismuth Bi = 210. Bi_4 (?) = 840.

15. BISMUTH **Bi = 210.**—A triad element, chiefly native in quartz: extracted by fusion. Hard, brittle, lustrous, reddish-white metal. Sp. gr. 9.799. Melts at 264°C. Crystallizes in rhomboids. Burns in Cl. HCl little action. HNO_3 dissolves it readily. Oxydizes readily at red heat. BISMUTHIC CHLORIDE $BiCl_3 = 316.5$. Fusible, volatile, deliquescent. By water, into BISMUTHIC OXY-CHLORIDE **BiOCl**. Thus: $BiCl_3 + H_2O = 2HCl + BiOCl$. "Pearl-white" is $2BiOCl,H_2O$, and insoluble in $H_2C_4H_4O_6$. *Prep.* of $BiCl_3$. *a.* By burning Bi in Cl; *b.* by distilling Bi with $HgCl_2$. $Bi_4 + 12HgCl_2 = 6Hg_2Cl_2 + 4BiCl_3$. BISMUTHIC BROMIDE $BiBr_3$. OXY-BROMIDE **BiOBr**. BISMUTHIC IODIDE BiI_3. OXY-IODIDE **BiOI**. **Bi and O.** BISMUTHOUS OXIDE **BiO**; is velvet-black. Burns in air to Bi_2O_3. Little known. BISMUTHIC OXIDE $Bi_2O_3 = 468$. Yellow powder, fusible at a red-heat. Basic. Its OXY-HYDRATE $BiHO_2$ or Bi_2O_3,H_2O; white, insoluble in KHO and in NH_3. *Prep.* of Bi_2O_3. By heating the nitrate to redness. BISMUTHIC NITRATE $Bi3NO_3,5H_2O$. Transparent prisms obtained by dissolving Bi in NHO_3. Diluted with water, decomposed into BISMUTHIC SUB-NITRATE $Bi_2O_3,2HNO_3$. A white powder, known as "Magistery of bismuth." BISMUTHIC ANHYDRIDE $Bi_2O_5 = 500$. Brown powder. By heating BISMUTHIC ACID $HBiO_3$, to 130°C. BISMUTHIC ACID $HBiO_3$. Red powder. Obtained by passing Cl through solution of KHO containing suspended Bi_2O_3. Thus: $Bi_2O_3 + 2Cl_2 + 4KHO = 4KCl + H_2O + 2HBiO_3$. **Bi** and **S**. BISMUTHIC SULPHIDE $Bi_2S_3 = 516$. Native in needles, as bismuth-glance. Sp. gr. 6.4. Precipitated from $BiCl_3$ by H_2S, as brown deposit. Insoluble in NH_4HS.

XVI. Boron B = 11. $B_2 = 22$.

16. BORON **B = 11.**—Molecular weight $B_2 = 22$. A triad element. Never native. Like carbon and silicon, in 3 allotropic modifications. B^a. Amorphous boron, a dull greenish powder,

burns to B_2O_3 when strongly ignited in air. Attacked by HNO_3, Cl, fusion with alkalies, &c. *Prep. a.* $\mathbf{B_2O_3} + 3Na_2 = 3Na_2O + \mathbf{B_2}$. *b.* $2\mathbf{BCl_3} + 3K_2 = 6KCl + \mathbf{B_2}$. *c.* $2(2KF,BF_3) + 3K_2 = 10KF + \mathbf{B_2}$. **Bβ.** Graphitoid boron, in scales of graphite-like lustre. Acids no action. *Prep.* $Al_2 + 2\mathbf{BCl_3} = 2AlCl_3 + 2\mathbf{B\beta}$. **Bγ** diamond boron, in square octohedra of cupreous lustre. Sp. gr. 2.68. Scratches rubies. *Prep.* $Al_2 + B_2O_3 = Al_2O_3 + \mathbf{B\gamma}$. BORON CHLORIDE $\mathbf{BCl_3} = 117.5$. Liquid of sp. gr. 1.35. Boils at 17°C. $BCl_3 + 3H_2O = 3HCl + HBO_2,H_2O$. *Prep.* of $\mathbf{BCl_3}$. $B_2O_3 + 3Cl_2 + 3C$ at bright-red heat $= 3CO + 2\mathbf{BCl_3}$. $\mathbf{BBr_3} = 251$. A liquid of sp. gr. 2.69. Boils at 90°C. BORON FLUORIDE $\mathbf{BF_3} = 68$. Colourless gas, irritating, irrespirable. Fumes in air. Water dissolves 700 vols. of the gas, and forms an acid, the HYDRO-FLUO-BORIC ACID $\mathbf{HF,BF_3}$. $4BF_3 + 3H_2O = HBO_2,H_2O + 3(\mathbf{HF,BF_3})$. *Prep.* of $\mathbf{BF_3}$. $B_2O_3 + 3CaF_2 + 3H_2SO_4 = 3(CaSO_4,H_2O) + 2\mathbf{BF_3}$. **B** and **O.** BORACIC ANHYDRIDE $\mathbf{B_2O_3} = 70$. Fuses to a transparent glass, which remains clear on cooling. *Prep.* by heating boracic acid to redness. $2(HBO_2,H_2O) = 3H_2O + \mathbf{B_2O_3}$. BORACIC ACID $\mathbf{HBO_2,H_2O} = 62$. Contained in the steam escaping from the fumerolles of Tuscany. In pearly scales, soluble in three parts of boiling water. Turns turmeric brown. Soluble in alcohol, and gives to the flame a green colour. Gradually decomposes carbonates. BORATES: those of the alkaline metals soluble in water. All borates soluble in HNO_3. At 100°: $2(HBO_2,H_2O) = 3H_2O + \mathbf{B_2O_3}$. "BORAX" is SODIUM BI-BORATE $Na_2B_4O_7,10H_2O$, the chief salt. The acid made from it: $Na_2B_4O_7 + 2HCl + 5H_2O = 2NaCl + 4(\mathbf{HBO_2},\mathbf{H_2O})$. [BORON NITRIDE $\mathbf{BN} = 25$. Grey mass, obtained by heating B in N, and by heating borax with ammonium chloride. $Na_2B_4O_7 + 4NH_4Cl = 2NaCl + 2HCl + 7H_2O + 4\mathbf{BN}$. Heated with potassium hydrate: $BN + 3KHO = NH_3 + K_3BO_3$.]

XVII. Silicon Si = 28.

17. SILICON **Si** = 28.—A tetrad element, never found native. Like carbon, in three allotropic modifications: **Siα.** *Amorphous.* A brown powder, only acted upon by HF, which dissolves it, with loss of $2H_2$, as $2HF,SiF_4$. Burns in air to SiO_2. *Prep.* of **Siα.** *a.* $2KF,\mathbf{SiF_4} + 2K_2 = 6KF + \mathbf{Si}$. *b.* Also: $\mathbf{SiCl_4} + 2K_2 = 4KCl + \mathbf{Si}$. **Siβ.** *Graphitoid.* Hexagonal plates of sp. gr. 2.49, with metallic lustre. Conducts electricity. Does not burn in O; slowly oxydized by mixed HF and HNO_3. *Prep.* of **Siβ**: by fusion of Siα with Al, and dissolving out the latter in HCl. **Siγ.** *Adamantine Silicon.* Steel-grey. *Prep.* of **Siγ.** By heating Al_2 in the vapour of $SiCl_4$. $3\mathbf{SiCl_4} + 2Al_2 = 2Al_2Cl_3 + \mathbf{Si_2}$. **Si with H.** SILICON HYDRIDE $\mathbf{SiH_4} = 32$. Colourless gas; inflames spontaneously in air; $SiH_4 + 2O_2 = 2H_2O + SiO_2$.

Prep. of SiH_4: $Mg_2Si + 4HCl = 2MgCl_2 + SiH_4$. [**Si with Cl.** SILICON CHLORIDE $SiCl_4 = 170$. Colourless, pungent, irritating liquid. Sp. gr. 1.52. Boils at 59°C. By water, into HCl and ORTHO-SILICIC ACID H_4SiO_4. $SiCl_4 + 4H_2O = 4HCl + H_4SiO_4$. *Prep.* of $SiCl_4$. *a.* By burning Si in $2Cl_2$. *b.* $SiO_2 + 2C + 2Cl_2 = 2CO + SiCl_4$. CHLORO-LEUKON $4HCl,SiCl_4$. Colourless, mobile liquid; fumes on exposure to air. Very inflammable; burns with greenish flame, depositing SiO_2 and evolving HCl. *Prep.* by transmitting HCl over Si heated to dull redness.]

Si with Br. [SILICON BROMIDE $SiBr_4 = 348$. Liquid of sp. gr. 2.813 at 0°. Boils at 153°C.] **Si with F.** SILICON FLUORIDE $SiF_4 = 104$. Colourless, pungent gas of sp. gr. 52, compared with H. Fumes in air, by decomposition with water. Condensible under pressure. *Prep.* of SiF_4. $SiO_2 + 2CaF_2 + 2H_2SO_4 = 2CaSO_4 + 2H_2O + SiF_4$. SILICO-FLUORIC ACID $2HF,SiF_4$; sour, fuming liquid. Salts silico-fluorides. A test for K. Thus: $2KHO + 2HF,SiF_4 = 2H_2O + 2KF,SiF_4$; from this latter salt, Si is prepared. *Prep.* of $2HF,SiF_4$. $3SiF_4 + 4H_2O = H_4SiO_4 + 2(2HF,SiF_4)$. **Si and O.** SILICIC ANHYDRIDE $SiO_2 = 60$. The most abundant of minerals. As "Rock crystal" in 6-sided, transversely-striated prisms, terminated by 6-sided pyramids. Insoluble in water. Fusible in oxy-hydrogen. Sp. gr. 2.69. Amethyst, cairngorm, agate, flint, carnelian, onyx, chalcedony, are varieties more or less pure of quartz or SiO_2. Opal contains H_2O. *Forms two acids.* Silicates. Most numerous. ORTHO-SILICIC ACID H_4SiO_4. White, gelatinous, when first precipitated. Soluble, until evaporated to dryness. Tetra-basic. At 100° into $2H_2O + SiO_2$. *Prep. a.* $SiF_4 + 4H_2O = 2(2HF,SiF_4) + H_4SiO_4$. *b.* $Na_4SiO_4 + 4HCl = 4NaCl + H_4SiO_4$. METASILICIC ACID H_2SiO_3. By evaporation of the former at 16°C., in vacuo. Meta-silicates are di-basic. Wollastonite $CaSiO_3$, is a meta-silicate. [LEUKON $Si_2H_4O_5$; snow-white powder, lighter than water. *Prep.* From leukon chloride by water. $Si_2H_4Cl_{10} + 5H_2O = 10HCl + Si_2H_4O_5$. CHRYSEON $C_2H_4O_4$. **Si with S.** SILICON SULPHIDE $SiS_2 = 92$. White, earthy mass. By water: $SiS_2 + 4H_2O = 2H_2S + H_4SiO_4$. *Prep.* $SiO_2 + CS_2$ (in vapour at a red heat) $= CO_2 + SiS_2$.]

XVIII. Titanium Ti = 50.

18. TITANIUM Ti = 50.—Tetrad element, never native. Discovered by Gregor in 1791. Both amorphous and in steel-grey crystals. Sp. gr. 5.3. *Prep.* of Ti. $TiCl_4 + 2Na_2 = 4NaCl + Ti$. **Compounds.** TITANIC CHLORIDE $TiCl_4$. Fuming volatile liquid, like $SiCl_4$. Obtained in same manner. TITANOUS-TITANIC CHLORIDE $TiCl_2,TiCl_4$. TRI-TITANIC TETRA-NITRIDE Ti_3N_4. Also a compound Ti_2N_2. **Ti with O.** TITANIC ANHYDRIDE $TiO_2 = 82$. Yel

lowish-white solid. After ignition, insoluble in all acids, except HF. In two modifications, soluble and insoluble. Native as "rutile" in reddish-brown prisms, isomorphous with tinstone; as "Brookite" in right-rhombic prisms, and as "anatase" in acute rhomboids. TITANIC ACID **H_2TiO_3**. Di-basic. Titanates. TITANOUS OXIDE **TiO**, black. Solution of H_2TiO_3 in HCl gives a purple, hydrated TiO_2,TiO_2xH_2O. TITANIC SULPHIDE **TiS_2**. N.B. The great distinction between SiO_2 and TiO_2 is that the latter is rendered soluble, after fusion with $KHSO_4$.

[XIX. Zirconium Zr = 89.5.]

[19. ZIRCONIUM **Zr = 89.5**.—A tetrad metal, closely resembling Si. An amorphous powder, assuming slight metallic lustre under the burnisher. Scarcely conducts electricity. Dissolved with ease by HF with formation of $2HF,ZF_4$. Also by aqua regia. *Prep.* of **Zr**. From POTASSIUM FLUO-ZIRCONATE **$2KF,ZF_4$** by heating with K. Thus: $2KF,ZrF_4 + 2K_2 = 6KF + Zr$. Zirconium burns magnificently when heated in O_2, to ZIRCONIUM OXIDE ZrO_2. **Compounds. Zr with Cl.** ZIRCONIUM CHLORIDE **$ZrCl_4$** in needles soluble in water and alcohol. **Zr with O.** ZIRCONIUM OXIDE **ZrO_2 = 121.5**. White, infusible substance, after ignition insoluble in acids. The hydrate is very gelatinous and *insoluble* in the alkalies. When neutral solutions of its salts are boiled with one of K_2SO_4, a sparingly soluble zirconium sub-sulphate is formed. $ZrSiO_4$ is found native as "zircon" and "hyacinth." Fused with KHO, saturated with HCl and evaporated to dryness: on addition of water, $ZrCl_4$ dissolves. To obtain ZrO_2, the solution is precipitated by NH_3, the precipitate washed and ignited. Zr is intermediate between Si and Ti; but it is more closely allied to Titanium.]

Examples of Calculations.

a. 135° C., how much on the scale of Fahrenheit? $135° = \frac{5}{9}$ [F. − 32°].

$$\therefore\ 243° = F. - 32°;\ \therefore\ F. = 275°.$$

b. − 4° F., how much on the scale of Centigrade?

$$C. = \tfrac{5}{9}[-4° - 32°] = 5 \times -4 = -20° C.$$

c. The latent heat of water is 143° F., what is this upon the scale of C.?

$$C. = \tfrac{5}{9} \times 143;\ \therefore\ C. = 79.4.$$

d. 10 lbs. of water at 100° C., are mixed with M lb. of ice at 0° C.; the temperature of the mixture is found to be 50° C. Find the value of M. in lbs.

$M \times 79.4 + M \times 50$ = amount absorbed by the ice. $10(100^\circ - 50^\circ)$ loss of heat of water.

$$\therefore M \times 129.4 = 500; \therefore M = 3.86 \text{ lbs.}$$

e. A cannon-ball weighing 1 lb. is placed in a vessel containing 1 lb. of water at 0° C.; without any evaporation, the water rises to 100° C. Find the temperature of the cannon-ball.

Let T be the temperature. $\therefore T - 100$ = loss of temperature of the cannon-ball. Also: 100 = the gain of temperature on the part of the water.

$$\therefore (T - 100^\circ) \times 1 \text{ lb.} \times 0.1138 = 100 \times 1 \text{ lb.} \times 1.$$

(0.1138 and 1 being respectively the sp. heats of iron and water.)

$$\therefore T = 978^\circ.73 \text{ C.}$$

f. What volume of carbonic anhydride can be obtained from 1000 grammes of calcium carbonate? Bar. 760 mm., Therm. 0° C.

$$100 : 1000 = 44; \therefore x = 440 \text{ grammes.}$$

11.19 litres of hydrogen weigh 1 gramme; $\therefore$ 11.19 litres of carbonic anhydride weigh 22 grammes.

$$\therefore 22 : 440 = 11.19 \; x = 223.8 \text{ litres.}$$

g. The capacity of a gasholder is 3357 litres. What weight of potassium chlorate will be required to fill it with oxygen at the standard temperature and pressure, supposing the potassium chlorate to give up all its oxygen?

11.19 litres of oxygen weigh 16 grammes.

$$\therefore 11.19 : 3357 = 16 \quad \therefore x = 4800 \text{ grammes.}$$

There are 48 grammes of oxygen in 122.5 grammes of potassium chlorate.

$$\therefore 48 : 4800 = 122.5; \; x = 12250 \text{ grammes.}$$

General Properties of the Metals.

Unless stated to the contrary, the metals are **elements**. They are good CONDUCTORS OF HEAT. According to Wiedemann and Franz they rank as follows:—

Silver	1000	Cadmium	577	Sodium	365
Gold	981	Iron, bar	436	Iron, cast	359
Copper, rolled	845	Tin	422	Lead	287
Copper, cast	811	Steel	397	Antimony	215
Aluminum	665	Platinum	380	Bismuth	61
Zinc, rolled	641				

They are also GOOD CONDUCTORS OF ELECTRICITY. As a rule, good conductors of heat are also good conductors of electricity. The conducting power of metals is inversely proportioned to their resistance to the passage of the electrical current. According to Matthiessen the electric conductivity of pure metals is as follows :—

Silver	100.00	Calcium	22.14	Palladium	12.64
Copper	77.43	Potassium	20.85	Platinum	10.53
Sodium	37.43	Lithium	19.00	Strontium	6.71
Aluminum	33.76	Iron	14.44	Mercury	1.63
Magnesium	25.47				

The following table of the SPECIFIC HEATS of the elements contrasted with water and ice is from Regnault :—

Water	1.0000	Phosphorus (red)	0.1700	Selenium	0.0827
Lithium	0.9408	Potassium	0.1696	Arsenicum	0.0814
Ice	0.5050	Diamond	0.1469	Silver	0.0570
Sodium	0.2934	Manganese	0.1217	Cadmium	0.0567
Magnesium	0.2499	Iron	0.1138	Tin	0.0562
Carbon	0.2414	Bromine	0.1129	Iodine	0.0541
Boron	0.2352	Nickel	0.1086	Antimony	0.0508
Aluminum	0.2143	Cobalt	0.1067	Mercury	0.0333
Sulphur	0.2026	Zinc	0.0955	Gold and Platinum	0.0324
Phosphorus	0.1887	Copper	0.0952	Bismuth	0.0308
Silicon	0.1774				

METALLIC LUSTRE, a feature of polished metals : wanting when in pulverulent state. OPACITY important : gold-leaf reflects green light. COLOUR varies from the whiteness of silver to the yellow of gold, the pale yellow of calcium and barium ; the red of copper, the bluish-white of lead, &c. Without ODOUR. INSOLUBLE in water. HARDNESS varies greatly ; from softness of butter, to hardness of steel. [Mohs' scale of hardness in minerals. **I. Talc** (23 specimens of minerals). **II. Gypsum** or **rock-salt** (90). **III. Calc-spar cleavable** (71). **IV. Fluorspar** (53). **V. Apatite** crystallized (43). **VI. Felspar cleavable** (26). **VII. Limpid quartz** (26). **VIII. Topaz** (5). **IX. Sapphire** or **corundum** (1). **X. Diamond** (1).] BRITTLENESS affected by temperature. Bi, Sb and As may be pounded. TENACITY measured by force required to break. If **Pb** 1, then **Cd** 1.2 **Sn.** 1.3. **Au** 5.6 **Zn** 8 **Ag** 8.9 **Pt** 13. **Pd** 15 **Cu** 17 **Fe** 26. MALLEABILITY the power of extension under rollers: **Au** first. **Ag, Cu, Pt, Pd, Fe, Al, Sn, Zn, Pb, Cd, Ni, Co.** Goldleaf $\frac{1}{250000}$ of an inch thick. DUCTILITY, involves tenacity, or power of resisting tension. **Au, Ag, Pt, Fe,**

and **Cu** much alike; then **Pd, Cd, Co, Ni, Al, Zn, Sn, Pb, T, Mg, L.** As to FUSIBILITY the metals rank thus:—

Mercury	−38°.8 C.	−37°.9 F.
Rubidium	38°.5 ,,	101°.3 ,,
Potassium	62°.5 ,,	144°.5 ,,
Sodium	97°.6 ,,	207°.7 ,,
Lithium	180° ,,	356° ,,
Tin	227° ,,	440° ,,
Cadmium	228° ,,	442° ,,
Bismuth	264° ,,	507° ,,
Thallium	294° ,,	561° ,,
Lead	325° ,,	617° ,,
Tellurium	326°.6 ,,	620° ,,
Zinc	412° ,,	773° ,,
Antimony	621° ,,	1150° ,,
Calcium	..	above redness.
Aluminum	..	above redness.
Silver	1023° ,,	1873° ,,
Copper	1091° ,,	1996° ,,
Gold	1102° ,,	2016° ,,
Cast iron	1530° ,,	2786° ,,

Pure iron, Nickel, Cobalt, Manganese, Palladium	wind-furnace.
Chromium, Molybdenum, Tungsten, Uranium	Imperfect fusion in wind-furnace.
Cerium, Iridium, Osmium, Platinum, Rhodium, Tantalum, Titanium	Fusible in oxy-hydrogen

VOLATILITY very various. **As, Hg, Te, Cd, Zn, K, Na** and **Ru** can be sublimed.

As to SPECIFIC GRAVITY, the metals exhibit great variations. (From Dr. Miller's "Chemistry.")

Lithium	0.593	Antimony	6.710
Potassium	0.865	Chromium	6.810
Sodium	0.972	Zinc	7.146
Rubidium	1.520	Tin	7.292
Calcium	1.578	Iron	7.844
Magnesium	1.743	Manganese	8.013
Glucinum	2.100	Cadmium	8.604–8.694
Strontium	2.540	Molybdenum	8.620
Aluminum	2.560–2.67	Nickel	8.820
Arsenicum	5.700–5.96	Copper	8.920–8.950
Tellurium	6.250	Cobalt	8.950

Bismuth . .	9.800	Mercury . .	13.596
Silver . . .	10.530	Tungsten . .	17.600
Lead . . .	11.360	Uranium . .	18.400
Ruthenium .	11.400	Gold . . .	19.340
Palladium . .	11.800	Iridium . .	21.150
Thallium . .	11·810–11.91	Osmium . .	21.400
Rhodium . .	12.100	Platinum . .	21.530

The metals often occur CRYSTALLLIZED; crystals are regular geometrical solids. [In certain positions, crystals split regularly: CLEAVAGE. The flat surfaces developed by cleavage called faces or planes. The lines of junction of two planes, its edges; junction of two edges, a plane angle; the point where three or more edges meet, a solid angle. Planes similar, when corresponding angles equal, and edges proportional; edges similar when produced by the meeting of planes respectively similar at equal angles; angles similar when equal, and contained within edges respectively similar. In crystals extra faces often formed by the replacement of an edge or the truncation of an angle. When faces quite equal and similar, called simple forms; those resulting from a combination of two or more simple ones, secondary or compound forms. Great variations in the angles of crystals; instruments of measurement called **Goniometers.** SIX CLASSES OF CRYSTALS. **I. The regular, tessular, or cubical system:** three equal axes around which the crystal symmetrically arranged, crossing each other at right angles. In cubes; salt, fluor, iron pyrites, alum, garnet, diamond, gold, silver, copper, lead, iron, mercury, &c.; in octohedra; alum, magnetite, chrome-iron ore, white arsenic, diamond and many metals: in tetrahedra; copper pyrites, grey copper ore or fahlerz, blende: in rhombic dodecahedra; cobalt-glance, garnet, diamond, fluor, and many metals. Crystals possessing the completest symmetry, called *homohedral* forms: those derived from the former, *hemihedral.*—**II. The right square prismatic, or pyramidal system.** Three axes at right angles to each other, two only equal,—the third axis longer or shorter. Includes the long square prism; tinstone, zircon, apophyllite, idocrase: the short square prism; zircon, &c.: the octohedral square prism: apophyllite, zircon, &c.; and the long square octohedron; anatase, tinstone, zircon, &c.—**III. The rhombic system.** Four axes; three of equal lengths in the same plane, crossing each other at angles of 60°, the fourth, perpendicular to these, may vary in length. The chief forms are; the obtuse rhombohedron; Iceland spar, tourmaline: the acute rhombohedron; Iceland spar: the hexagonal prism; emerald, quartz, tourmaline; the bi-pyramidal dodecahedron; quartz, apatite; and the scalene dodecahedron; calcite or dogtooth spar.—**IV. The right rectan-**

gular prismatic system. Three axes, all unequal and all at right angles to each other. Includes the right rectangular prism; heavy spar, prehnite, nitre:—the right rhombic prism: topaz, sulphur, prehnite, heavy spar; the octohedral rhombic prism: topaz, sulphur:—and the rhombic octohedron; harmatome, sulphur, topaz, &c.—**V. The oblique system.** The three axes may all be of unequal length; two cross obliquely, the third is perpendicular to the others. Includes: the oblique rectangular prism; felspar, epidote, mica:—the oblique rhombic prism; selenite, augite, sphene:—and the oblique rhombic octohedron; felspar, selenite, &c.—**VI. The doubly oblique** or **anorthic system.** All the axes of unequal length and all cross obliquely. Includes: the doubly oblique prism; axinite, blue vitriol, &c.:—and the doubly oblique octohedron; albite, axinite.] When a body crystallizes in two irreconcileable forms, it is said to be DIMORPHOUS; when in three, TRIMORPHOUS. Pulverulent bodies, without any regular form, are called AMORPHOUS. Crystallized bodies, with similarity in form and analogy of composition, are called ISOMORPHOUS. E. g. **KCl. KI. KF. K(CN)**.

B. *The metallic elements and their compounds.*

1. *Metals of the alkalies.* They displace **one** atom of hydrogen from the acids; hence **monad** metals. The group includes **Potassium, Sodium, Lithium, Caesium, Rubidium,** and the compound metal **Ammonium.** Their oxides and hydrates are soluble in water and strongly alkaline to test-paper. Their carbonates are also soluble and alkaline in reaction.

I. Potassium or Kalium K = 39. K_2 = 78.

1. KALIUM OR POTASSIUM **K = 39.**—Molecular weight K_2 = **78.** Discovered by Davy in 1807. Brilliantly white metal, volatile at a red-heat with green vapour. Sp. gr. 0.865. Melts at 58·C. Oxydizes rapidly: must be kept under naphtha or hermetically sealed from the air. Decomposes H_2O, the H_2 burning with rose-coloured flame: dissolves as POTASSIUM HYDRATE KHO. Absorbs CO and yields POTASSIUM RHODIZONATE $K_2C_6H_2O_6,H_2O$. *Prep. a* by electrolysis of moist POTASSIUM HYDRATE KHO. K_2 at the zincode. *b.* By heating POTASSIUM CARBONATE K_2CO_3 with charcoal: $K_2CO_3 + 2C = 3CO + K_2$. *c.* By heating KHO to whiteness with iron filings: $4KHO + 3Fe = Fe_3O_4 + 2H_2 + 2K_2$. **Three oxides: one basic oxide.** POTASSIUM OXIDE K_2O. White, deliquescent, caustic solid. Prepared by oxydizing K_2 in dry O_2. Or by heating 2KHO with Potassium: $2KHO + K_2 = H_2 + 2K_2O$. POTASSIUM HYDRATE OF CAUSTIC POTASH **KHO.** Hard greyish-white, deliquescent solid. Sp. gr. 2.2. Blues red litmus. Fuses without losing water. Rose colour to flame.

Next to Caesium and Rubidium hydrates, the most powerful base. Precipitates METALLIC HYDRATES from their respective salts: $CaCl_2 + 2KHO = 2KCl + CaH_2O_2$. $FeCl_2 + 2KHO = 2KCl + FeH_2O_2$. Contained in felspar, mica, &c. Dissolves in one-half its weight of water, heats and forms a second HYDRATE **$KHO,2H_2O$**, in acute rhomboids. Soluble also in ethylic alcohol. Liquor potassæ of Pharmacy contains about 6 per cent. of KHO. *Prep.* of **KHO**. By dissolving K_2CO_3 in 10 parts of H_2O, adding half the weight of the salt of Calcium hydrate, boiling, decanting, evaporating and fusing the residue: $K_2CO_3 + CaH_2O_2 = CaCO_3 + 2KHO$. [TETROXIDE **$K_2O_4$**; by heating K_2 in O_2. A yellow solid, decomposed by H_2O into O_2, and POTASSIUM DIOXIDE **K_2O_2**.] POTASSIUM SULPHIDE **K_2S**. From **K_2SO_4** $+ 4C = 4CO + K_2S$. Or: **K_2S_4** $+ 2H_2 = 2H_2O + K_2S$. Pyrophoric. HYDROGEN SULPHIDE **KHS**, by saturating **KHO** with H_2S. Thus: **KHO** $+ H_2S = H_2O +$ **KHS**. Changed by air into DI-SULPHIDE **K_2S_2**. [TRI-SULPHIDE **K_2S_3**. TETRASULPHIDE **K_2S_4**. PENTASULPHIDE **K_2S_5**. $6KHO + 6S_2 = K_2S_2H_2O_4 + 2H_2O + 2K_2S_5$.]

Salts of Potassium, soluble in water. CHLORIDE **KCl**. White cubes, soluble in 3 of water. In sea-water and in kelp (25 per cent.). Fusible, and volatile at high temperatures. BROMIDE **KBr**, also in cubes. Used for making Bromine. $2KBr + MnO_2 + 2H_2SO_4 = K_2SO_4 + MnSO_4 + 2H_2O + Br_2$. IODIDE **KI**. White cubes, very soluble. Browns when it contains POTASSIUM IODATE **KIO_3**, on addition of Tartaric acid. *Prep.* $6KHO + 3I_2 = KIO_3 + 3H_2O + 5KI$. Then by gentle heat: $2KIO_3 = 3O_2 + 2KI$. Also: $Fe + I_2 = FeI_2$. Then $FeI_2 + K_2CO_3 = FeCO_3 + 2KI$. FLUORIDE **KF**, in deliquescent cubes. Source of SILICON. $2KF,SiF_4 + 2K_2 = 6KF + Si$. CYANIDE **KCy**, in deliquescent cubes. SULPHATE **K_2SO_4**, in hard, 6-sided prisms, terminating in 6-sided pyramids. Soluble in 16 of H_2O. Decrepitates when heated. HYDROGEN SULPHATE **$KHSO_4$**, in flattened rhomboidal prisms, soluble in 2 of water. Residuum in the manufacture of HNO_3, when KNO_3 employed. $KNO_3 + H_2SO_4 = HNO_3 +$ **$KHSO_4$**. **Potassium carbonate K_2CO_3**; the pearl-ash of commerce. Obtained by incinerating plants. White, granular, deliquescent, alkaline. Crystallizes as **$K_2CO_3,2H_2O$**. HYDROGEN CARBONATE **$KHCO_3$**. In right-rhombic prisms, soluble in 4 of H_2O. By solution in hot water, into SESQUI-CARBONATE **$2K_2CO_3,H_2CO_3$**. By heat into K_2CO_3. ORTHO-SILICATE **K_4SiO_4**, or $2K_2O,SiO_2$. SILICATE **K_2SiO_3**. Crown-glass is $K_2O,2SiO_2.CaO,2SiO_2$. Bohemian glass for chemical purposes $K_2O,3SiO_2.CaO3SiO_2$. That employed for ornaments: $3(KCa)O,Al_2O_3,12SiO_2$. NITRATE **KNO_3**. Nitre or saltpetre. In 6-sided striated prisms with dihedral summits. Soluble in $3\frac{1}{2}$ of cold and $\frac{1}{3}$ of boiling water. Cooling, saline taste. Insoluble in alcohol. Fuses at 339° C.: *sal prunelle*. By continued heat into POTASSIUM NITRITE **KNO_2**; finally into $O_2 +$

$N_2 + K_2O_2$. Gunpowder, a mixture of 2 atoms of potassium nitrate, 3 atoms of charcoal, and 1 atom of sulphur. When fired: $4KNO_3 + S_2 + 6C = 2K_2S + 2N_2 + 6CO_2$. The expansion 1500 times that of the powder. CHLORATE **$KClO_3$**. Rhomboidal scales of pearly lustre, soluble in 16 of cold and 2 of boiling H_2O. Melts at about 400° C. By heat: $2KClO_3 = 2KCl + 3O_2$. More carefully heated, into PERCHLORATE **$KClO_4$**. $2KClO_3 = O_2 + KCl + KClO_4$. By nitrous anhydride: $N_2O_3 + 2KClO_3 = 2KNO_3 + Cl_2O_3$. By oil of vitriol: $2H_2SO_4 + 3KClO_3 = 2KHSO_4 + KClO_4 + H_2O + 2ClO_2$. *Prep.* $6KHO + 3Cl_2 = 3H_2O + 5KCl + KClO_3$. Also from $Ca2ClO_3 + 2KCl = CaCl_2 + 2KClO_3$. Separated by crystallization. PERCHLORATE **$KClO_4$**, in needles, requiring 60 parts of H_2O for solution. **Insoluble salts**: POTASSIUM PLATINIC CHLORIDE **$2KCl,PtCl_4$**, a yellow salt, insoluble in a mixture of ethylic alcohol and ether, and with difficulty soluble in water. One hundred parts of the salt contain 15.98 of Potassium, or 19.26 of Potassium oxide. POTASSIUM SILICO-FLUORIDE **$2KF,SiF_4$**, a white powder. Gelatinous when first precipitated. The salt used for making **Si**. P. 24.

II. Sodium or Natrium Na = 23. Na_2 = 46.

2. NATRIUM **Na = 23**. Molecular weight $Na_2 = 46$. A beautiful reddish-white crystalline metal, less lustrous than Potassium. Sp. gr. 0.972. Fuses at 98° C. Volatile. Burns with yellow flame. Decomposes water. $Na_2 + 2H_2O = H_2 + 2NaHO$. *Prep.* **$Na_2CO_3$** + 2C = 3CO + **$Na_2$**. Sodium is a great reducing agent. **Two oxides: one basic oxide.** SODIUM OXIDE **Na_2O**, resembles **K_2O**. SODIUM HYDRATE **NaHO**. White, fusible, deliquescent solid. *Prep.* **Na_2CO_3** dissolved + $CaH_2O_2 = CaCO_3 + 2NaHO$. PEROXIDE **$Na_2O_2$**. By burning Na_2 in O_2. [SODIUM SULPHIDES. **$Na_2S.Na_2S_2.Na_2S_3.Na_2S_4.Na_2S_5$.**] **Sodium salts: soluble in water. Sodium chloride NaCl.** Is "common salt," the chief salt of sodium. Cubes, soluble in 3 of cold water; saturated solution has a sp. gr. of 1.205 and boils at 110° C. Fuses and volatilizes. Antiseptic. Source of Sodium hydrogen sulphate, then of Sodium sulphate and of Hydrochloric acid (p. 14) *a.* $2NaCl + H_2SO_4 = HCl + NaHSO_4 + NaCl$. *b.* $NaCl + NaHSO_4 = HCl + Na_2SO_4$. BROMIDE **NaBr**, in sea-water. IODIDE **NaI**, in sea-water and in kelp. In cubes. Source of **Iodine I** (p. 16). $2NaI + MnO_2 + 2H_2SO_4 = Na_2SO_4 + MnSO_4 + 2H_2O + I_2$. SULPHATE **$Na_2SO_4 10H_2O$**. In 4-sided prisms soluble in 2 of water. Effloresces and loses all its water. Aperient: "Glauber's salt." Made from NaCl. HYDROGEN SULPHATE **$NaHSO_4$**. Very acid. Non-deliquescent. By heat, first: $2NaHSO_4 = H_2O + Na_2SO_4.SO_3$. Then, if the temperature raised: $Na_2SO_4 + SO_3$. SULPHITE **$Na_2SO_3 10H_2O$**. Oblique prisms. Efflo-

rescent. In 4 of cold water. HYPO-SULPHITE $\mathbf{Na_2S_2H_2O_4,4H_2O}$. In oblique prisms. Made by digesting Sulphur in solution of Sodium sulphite. Used in photography. SODIUM CARBONATE $\mathbf{Na_2CO_3,10H_2O}$, in oblique rhombic prisms, soluble in 2 of water. Effloresces. Fusible. *Prep. a.* Of *salt-cake.* $2NaCl + H_2SO_4 = 2HCl + Na_2SO_4$. *b.* Of *black-ash.* $Na_2SO_4 + 4C = 4CO + Na_2S$. $5Na_2S + 7CaCO_3 = 2CaO,5CaS + 2CO_2 + 5\mathbf{Na_2CO_3}$. N.B. Black-ash contains from 20–27 per cent. of Sodium oxide, as the Carbon at the high temperature removes CO_2 as 2CO. The solution evaporated and roasted in a reverberatory furnace with sawdust. Re-dissolved and crystallized. SESQUI-CARBONATE $\mathbf{2Na_2CO_3,H_2CO_3,2H_2O}$, in rhombic prisms, terminated by 4-sided pyramids. Found as "Natron" and "Trona salt." HYDROGEN CARBONATE $\mathbf{NaHCO_3}$. A white powder, soluble in 10 of H_2O. Feebly alkaline. Does not precipitate Magnesia. SILICATE $\mathbf{Na_2SiO_3}$. ORTHO-SILICATE $\mathbf{Na_4SiO_4}$. Fuchs's soluble glass is $\mathbf{Na_2O,4SiO_2}$. GLASS is a mixture of various silicates. In window-glass, chiefly Sodium and Calcium silicates. Soda-glass more brilliant than Potash-glass, but with a greenish tint. BI-BORATE $\mathbf{Na_2B_4O_7,10H_2O}$. "Borax." Native in Thibet. Called Tincal in commerce. In flattened 6-sided prisms, with tri-hedral summits. Soluble in 12 of cold and half their weight of boiling H_2O. By heat intumesces, loses all its water and melts into a clear bead of $Na_2B_4O_7$. Solvent of metallic oxides. A good flux. By HCl into NaCl and BORACIC ACID HBO_2,H_2O (p. 24). NITRATE $\mathbf{NaNO_3}$. Native in Atacama, Iquique, &c. In obtuse rhomboids, soluble in 2 of H_2O. Somewhat deliquescent. 85 parts $NaNO_3$ yield as much HNO_3 as 101 parts of KNO_3. PHOSPHATES. *a.* ORTHO-PHOSPHATES: tri-basic. DI-SODIUM HYDROGEN PHOSPHATE $\mathbf{Na_2HPO_4,12H_2O}$. The common rhombic phosphate. Oblique, rhombic prisms of saline taste, soluble in $4H_2O$. By adding NaHO, we obtain H_2O and: TRI-SODIUM PHOSPHATE $\mathbf{Na_3PO_4,12H_2O}$, in 6-sided prisms. By adding ORTHO-PHOSPHORIC ACID H_3PO_4 to di-sodium hydrogen phosphate, we obtain two atoms of SODIUM DI-HYDROGEN PHOSPHATE $\mathbf{NaH_2PO_4}$. SODIUM AMMONIUM HYDROGEN PHOSPHATE $\mathbf{NaNH_4HPO_4,4H_2O}$. "Microcosmic salt." Transparent, efflorescent prisms. *Prep.* $Na_2HPO_4 + NH_4Cl = NaCl + \mathbf{NaNH_4HPO_4}$. *b.* PYRO-PHOSPHATES: tetra-basic. SODIUM PYRO-PHOSPHATE $\mathbf{Na_4P_2O_7,10H_2O}$. In prisms. By heating Na_2HPO_4 to low redness and crystallizing from H_2O. Thus, $2Na_2HPO_4 = H_2O + \mathbf{Na_4P_2O_7}$. *c.* META-PHOSPHATES: mono-basic. SODIUM META-PHOSPHATE $\mathbf{NaPO_3}$. Transparent, glass-like mass. By igniting $NaH_2PO_4 = H_2O + \mathbf{NaPO_3}$. Or by igniting $NaNH_4HPO_4 = H_2O + NH_3 + \mathbf{NaPO_3}$. SODIUM PLATINIC CHLORIDE $\mathbf{2NaCl,PtCl_4}$, in striated, yellow prisms, very soluble in water. **Insoluble salt.** DI-HYDRIC PYR-ANTIMONATE $\mathbf{Na_2H_2Sb_2O_7,6H_2O}$.

[III. Lithium L = 7. Molecular weight L_2 = 14.

3. LITHIUM **L = 7.** Molecular weight **L_2 = 14.** A white lustrous metal, fusible at 180 C. Sp. gr. 0.59. The lightest solid. From λίθος, a stone. Very oxydizable. Volatile at a red-heat *Prep.* By electrolysis from fused LITHIUM CHLORIDE LCl; **L** at the zincode. **One oxide: basic.** LITHIUM OXIDE **L_2O.** Discovered by Arfwedson in 1818. LITHIUM HYDRATE **LHO.** Far less soluble than KHO and NaHO. Fuses below red-heat and destroys Platinum vessels. Lithium salts in various mineral waters and in the ashes of plants. In rare minerals, such as: "Lepidolite" $(LK)F,Al_2O_3,3SiO_2$; "Spodumene" or "Triphane" $3(LNa)_2O,4Al_2O_3,15SiO_2$, and "Petalite" $3(LNa)_2O,4Al_2O_3,30SiO_2$. **Salts.** CHLORIDE **$LCl,2H_2O$**, most deliquescent. Above 15°C. in anhydrous octohedra. Very soluble in a mixture of equal vols. of ethylic alcohol and ether, in which KCl and NaCl insoluble. Purple colour to flame. CARBONATE **L_2CO_3.** Alkaline, sparingly soluble. SULPHATE **L_2SO_4,H_2O**, in flat tables, very soluble. ORTHO-PHOSPHATE **L_3PO_4, insoluble** in alkaline solutions and in alkaline phosphates.

Lithium sulphate is made from any of the above-named minerals. Finely pounded, and ignited with twice their weight of Calcium oxide, the mass is first treated with Hydrochloric acid, then with Sulphuric acid, and the L_2SO_4 dissolved out from the $CaSO_4$. By means of solution of Barium hydrate, the L_2SO_4 is changed into LHO. $L_2SO_4 + BaH_2O_2 = BaSO_4 + 2LHO$.]

[IV. Caesium Cs = 133.

4. CAESIUM Cs = 133. Discovered by Bunsen and Kirchoff in 1860 in a spring at Durkheim. Like Potassium, but more electro-positive. The name from *caesius*, lavender-blue, on account of the two blue bands produced by it in the spectrum of a gas-flame. Also in a rare mineral from Elba, "Pollux," which contains 32 per cent. **Two oxides: one basic.** CAESIUM OXIDE **Cs_2O.** HYDRATE **CsHO**; very deliquescent and caustic. Most powerful base. **Salts.** CAESIUM CHLORIDE **CsCl**, in cubes. In the Nauheim spring. SULPHATE **Cs_2SO_4**; very soluble. CARBONATE **Cs_2CO_3**, white, deliquescent. HYDROGEN CARBONATE **$CsHCO_3$.** CAESIUM PLATINIC CHLORIDE **$2CsCl,PtCl_4$**, in yellow octohedra. The most **insoluble** of the platinic salts.]

[V. Rubidium Rb = 85.36.

5. RUBIDIUM **Rb** = 85.36. A brilliant silver-white metal of sp. gr. 1.52. Melts at 38°5 C. Volatile, with blue vapour at a red-heat. Resembles Potassium, but is yet more electro-positive. Discovered by Bunsen and Kirchoff. The name from *rubidus*,

dark-red, from a pair of red lines in the spectrum. It is found together with Caesium and Thallium, as chloride in the mother-liquor of the Nauheim spring; in the ashes of some plants and in a variety of Lepidolite. **One basic oxide.** RUBIDIUM OXIDE **Rb_2O**. HYDRATE **$RbHO$**, a most powerful base. **Salts.** RUBIDIUM CHLORIDE **$RbCl$**, in non-deliquescent cubes. CARBONATE **Rb_2CO_3**. Deliquescent. In minute quantities in ash of tobacco, beet-root, and many others. SULPHATE **Rb_2SO_4**, in hard 6-sided prisms, erminated in 6-sided pyramids. RUBIDIUM PLATINIC CHLORIDE **$2RbCl,PtCl_4$**, only less soluble than Caesium platinic chloride.]

Ammonium (NH_4) = 18.

AMMONIUM $NH_4 = 18$. Hypothetical metal. In its combinations, the most perfect analogy with the alkaline metals, especially Potassium. Many of its salts isomorphous. Ammonium-amalgam formed by the action of Sodium-amalgam upon Ammonium chloride. $Na_2Hg_2 + 2NH_4Cl = 2NaCl + 2NH_4Hg_2$. Breaks up spontaneously into H_2,Hg and NH_3. NITROGEN HYDRIDE **NH_3**. **Ammonia** (p. 6). AMMONIDES. AMMONIDE SULPHITE **$(NH_3)_2SO_2$**. AMMONIDE SULPHATE **$(NH_3)_2SO_3$**. By water into: AMMONIUM SULPHITE **$(NH_4)_2SO_3$** and SULPHATE **$(NH_4)_2SO_4$**. **Salts.** AMMONIUM HYDROGEN SULPHIDE **NH_4HS** (p. 10). CHLORIDE **NH_4Cl**, in fibrous masses, or fern-shaped crystals, soluble in less than 3 parts of H_2O. Sublimes without fusion. **$NH_3 + HCl = NH_4Cl$.** Made from gas-liquors. NITRATE **NH_4NO_3**. By heat $= 2H_2O + N_2O$. In striated prisms. NITRITE **NH_4NO_2**. By heat $= 2H_2O + N_2$. SULPHATE **$(NH_4)_2SO_4$**, in prisms, soluble in 2 of cold water. CARBONATE **$(NH_4)_2CO_3$**, not known as a solid. SESQUI-CARBONATE **$2[(NH_4)_2CO_3]CO_2$**. The smelling-salts of the shops. By loss of AMMONIDE CARBONATE **$(NH_3)_2CO_2$**, into AMMONIUM HYDROGEN CARBONATE **NH_4HCO_3**, and so becomes soft and white. $2[(NH_4)_2CO_3]CO_2 = (NH_3)_2CO_2 + 2(NH_4)HCO_3$. *Prep.* By subliming NH_4Cl with $CaCO_3$. Thus: $6NH_4Cl + 3CaCO_3 = 3CaCl_2 + H_2O + 2NH_3 + 2[(NH_4)_2CO_3],CO_2$. SODIUM AMMONIUM HYDROGEN PHOSPHATE **$NaNH_4HPO_4,4H_2O$**, is "microcosmic salt" (p. 34). AMMONIUM PLATINIC CHLORIDE **$2NH_4Cl,PtCl_4$**, yellow, insoluble in mixed alcohol and ether, contains **7.62** per cent. of **NH_3**. Estimated as $2NH_4Cl,PtCl_4$.

2. Metals of the alkaline earths.

Includes **Barium, Strontium,** and **Calcium.** They decompose water at common temperatures. Their hydrates soluble in water, with strong alkaline reaction. Carbonates insoluble. Can be separated from the alkalies by boiling with $(NH_4)_2CO_3$. Most of their salts insoluble in water. **Dyad metals:** 1 atom of the metals displaces 2 atoms of Hydrogen.

VI. Barium Ba = 137.

6. BARIUM **Ba = 137.** Metal of pale-yellow colour, very oxydizable. Fusible at a red-heat. Name from βαρὺς, heavy. *Prep.* From fused BARIUM CHLORIDE $BaCl_2$, by electrolysis; **Ba** at zincode. **Two oxides: one basic oxide.** BARIUM OXIDE **BaO.** Baryta. Grey and fusible. HYDRATE $\mathbf{BaH_2O_2}$, crystallizes with $\mathbf{8H_2O}$; in scales. soluble in 20 of cold and 2 of boiling H_2O; solution strongly alkaline. Great affinity for CO_2 and SO_3. Employed in making KHO. $K_2SO_4 + BaH_2O_2 = BaSO_4 + 2KHO$. Very poisonous: antidote $Na_2SO_4,10H_2O$ and $MgSO_4,7H_2O$. *Prep. a.* Heating $Ba2NO_3$ to redness. *b.* By boiling $6BaS + 6H_2O + 8CuO = 4Cu_2S + BaS_2H_2O_4 + 5\mathbf{BaH_2O_2}$. PEROXIDE $\mathbf{BaO_2}$. Grey. HYDRATE $\mathbf{BaO_2,6H_2O}$. Used for making HYDROGEN PEROXIDE $\mathbf{H_2O_2}$ (p. 6). Also a source of oxygen. *Prep.* BaO heated in a stream of pure air = $\mathbf{BaO_2}$. By fusing $\mathbf{3BaO + KClO_3} = KCl + 3\mathbf{BaO_2}$: then by water, which dissolves KCl, and leaves insoluble $\mathbf{BaO_2 6H_2O}$. SULPHIDE **BaS.** Igniting $BaSO_4 + 4C = 4CO + \mathbf{BaS}$. HYDRATE $\mathbf{BaS,6H_2O}$ in colourless crystals. When dissolved: $2BaS + 2H_2O = BaH_2O_2 + BaSH_2S$. Barium sulphide used for making soluble barium salts. **Salts: soluble.** CHLORIDE $\mathbf{BaCl_2,2H_2O}$ in flat 4-sided tables, soluble in 2½ of water. Yellowish-green colour to flame. Chief test for soluble SULPHATES, carbonates, phosphates, borates, &c., as all insoluble in water, but all soluble in acids except Barium sulphate. NITRATE $\mathbf{Ba2NO_3}$, octohedra, soluble in 8 parts of cold and 3 of boiling water. Less soluble in HCl and in HNO_3, than in H_2O. A mixture of 45 parts of dry $Ba2NO_3$, 15 of S, 10 of $KClO_3$, 2½ of lamp-black, and 1½ of antimonous sulphide, constitutes *green-fire.* CHLORATE $\mathbf{Ba2ClO_3}$. Beautiful green colour to flame. ACETATE $\mathbf{Ba2C_2H_3O_2,3H_2O}$, in flattened prisms. **Insoluble salts. Barium sulphate** $\mathbf{BaSO_4}$. Native as "heavy spar," in rhombic prisms and massive. Sp. gr. 4.59. Used as white paint to adulterate white lead, but insoluble in HNO_3. Source of Ba salts. Rendered soluble by igniting with C. **Carbonate** $\mathbf{BaCO_3}$. Native as "Witherite" in 6-sided prisms, terminated in 6-sided pyramids. White powder, soluble in diluted HNO_3 and HCl as nitrate and chloride. SILICO-FLUORIDE $\mathbf{BaF_2,SiF_4}$. CHROMATE $\mathbf{BaCrO_4}$, yellow. BARIUM is weighed as $\mathbf{BaSO_4}$, 100 parts of which contain 65.66 of **BaO.**

VII. Strontium Sr = 87.5.

7. STRONTIUM Sr = 87.5. A malleable metal of pale-yellow colour, burning with crimson flame. Sp. gr. 2.54. The name from "Strontianite," a carbonate found at Strontian in Scotland. *Prep.* From fused $SrCl_2$; **Sr** at zincode. **Two oxides: one basic oxide.** STRONTIUM OXIDE **SrO.** White. From $Sr2NO_3$,

at a red-heat. HYDRATE **$SrH_2O_2,8H_2O$**, in scales, requiring 50 parts of cold and 24 of boiling H_2O. Great affinity for CO_2 and SO_3. Loses $8H_2O$ by heat [STRONTIUM PEROXIDE **SrO_2**. By adding H_2O_2 to SrH_2O_2. Thus: $SrH_2O_2 + H_2O_2 = 2H_2O + SrO_2$.] SULPHIDE **SrS**. From $SrSO_4 + 4C = 4CO + SrS$. **Salts of strontium: soluble in water.** CHLORIDE **$SrCl_2,6H_2O$**. Deliquescent needles. Very soluble in ethylic alcohol: thus is $SrCl_2$ separated from $BaCl_2$. Solution burns with crimson flame. NITRATE **$Sr2NO_3$**, octohedra soluble in 5 of H_2O. Also with **$5H_2O$** at low temperatures. "Red-fire" a mixture of 40 parts of $Sr2NO_3$, 10 of $KClO_3$, 13 of S, 4 of Sb_2S_3. Requires great care in mixing. [ACETATE **$Sr2C_2H_3O_2$**. CHROMATE **$SrCrO_4$**, yellow and somewhat soluble. SILICO-FLUORIDE **SrF_2,SiF_4**, much more soluble than BaF_2,SiF_4.] **Insoluble. Sulphate $SrSO_4$**, native as "Celestine," in rhombic prisms, or massive. Often accompanies S in Sicily. By ignition with 4 C, into SrS + 4CO. **Carbonate $SrCO_3$**, native as "Strontianite," in Argyleshire. [OXALATE **SrC_2O_4,H_2O**, white. PHOSPHATE **$SrHPO_4$**, white.] STRONTIUM is estimated as **$SrSO_4$**; it contains 56.52 per cent. of **SrO**.

VIII. Calcium Ca = 40.

8. CALCIUM **Ca = 40.** Light-yellow metal, oxydizing readily. Very malleable. Fusible at a red-heat. Sp. gr. 1.578. Burns vividly with white light to calcium oxide CaO. Prepared by Matthiessen from a fused mixture of $2CaCl_2$, with $SrCl_2$, by electrolysis: **Ca** at the zincode. **Two oxides: one basic oxide.** CALCIUM OXIDE **CaO**. "Lime" and "quick-lime." White, caustic, infusible. In oxy-hydrogen, an intense white light. With H_2O it *slakes* and forms CALCIUM HYDRATE **CaH_2O_2**, soluble in 700 parts of cold and 1280 parts of boiling water: "Lime-water." Excess of calcium hydrate in water, called "Milk of lime." CaO used in gas-purification for the absorption of CO_2 and of H_2S. CaH_2O_2, in making KHO from K_2CO_3; also in mortars, cements, &c. $CaH_2O_2 + CO_2 = H_2O + CaCO_3$. *Prep.* By heating CALCIUM CARBONATE **$CaCO_3$** to redness. **$CaCO_3 = CO_2 + CaO$**. [CALCIUM PEROXIDE **CaO_2**. By action of H_2O_2 upon $CaH_2O_2 = 2H_2O + CaO_2$.] CALCIUM SULPHIDE **CaS**, white, insoluble in cold, decomposed by boiling water. **$CaSO_4 + 4C = 4CO + CaS$**. [When moist, absorbs oxygen: $2CaS + 2H_2O + 2O_2 = CaS_2H_2O_4 + CaH_2O_2$. PENTASULPHIDE **$CaS_5$**. By boiling S_2 with CaH_2O_2. $3CaH_2O_2 + 6S_2 = 2H_2O + CaS_2H_2O_4 + 2\,CaS_5$. PHOSPHIDE **CaP**. By distilling P_4 with CaO. $28CaO + 7P_4 = 4Ca_2P_2O_7 + 20\,CaP$. DI-SILICIDE **$CaSi_2$** in lead-grey scales. By HNO_3, into CHRYSEON **$Si_2H_2O_4$**]. **Salts of calcium: soluble in water. Chloride $CaCl_2$, $6H_2O$**, in striated, deliquescent prisms; saturated solution boils at 179.5°C. By heat loses water, and

is then a great desiccator. Found in sea-water. Artificially: $\mathbf{CaCO_3}+\mathbf{2HCl}=H_2O+CO_2+\mathbf{CaCl_2}$. Crystallizes with $4C_2H_5O$. Absorbs NH_3. [CALCIUM BROMIDE $\mathbf{CaBr_2}$. IODIDE $\mathbf{CaI_2}$. Employed for making **Ca**. $\mathbf{CaI_2}+Na_2=2NaI+\mathbf{Ca}$. OXY-CHLORIDE $\mathbf{CaOCl_2}$. Known as "Chloride of lime." Evolves Cl_2 when exposed to the air. Made by absorption of Cl_2 by CaH_2O_2 $=H_2O+\mathbf{CaOCl_2}$. NITRATE $\mathbf{Ca2NO_3,4H_2O}$, deliquescent prisms. CHLORATE $\mathbf{Ca2ClO_3}$, deliquescent. ACETATE $\mathbf{Ca2C_2H_3O_2}$, silken needles, very soluble.] CALCIUM BI-CARBONATE $\mathbf{CaCO_3,CO_2}$, in calcareous waters. Soluble in 400 parts of cold water. Deposited as "Stalactites" and "Stalagmites." Temporarily hard waters contain $CaCO_3,CO_2$; softened by boiling. **Sulphate** $\mathbf{CaSO_4,2H_2O}$. Transparent, flattened prisms as "Selenite." Rectangular prisms as "Anhydrite." Massive as "Alabaster." Soluble in 400 of water. Heated below 260°C., loses water and forms "Gypsum," or "Plaster of Paris" $CaSO_4$. Contained in all spring waters. SUPERPHOSPHATE $\mathbf{CaH_42PO_4}$, soluble in H_2O. Used as manure and in making $\mathbf{P_4}$ (p. 18). **Insoluble calcium salts. Calcium carbonate** $\mathbf{CaCO_3}$. As "marble" "limestone," "oolite," &c. In coral, shells, &c. Dimorphous: in rhomboids in "Iceland spar," and in 6-sided, right rhombic prisms in "Aragonite." White, pulverulent in "Chalk," and when precipitated: $\mathbf{CaCl_2}+Na_2\mathbf{CO_3}=2NaCl+\mathbf{CaCO_3}$. Stalactites are $CaCO_3$. **Calcium fluoride** $\mathbf{CaF_2}$. In cubes and octohedra as "Fluorspar." For ornaments and for making HF and $2HF,SiF_4$. $CaF_2+\mathbf{H_2}SO_4=CaSO_4+2\mathbf{HF}$ (p. 17). **Calcium ortho-phosphate** $\mathbf{Ca_32PO_4}$. Native as "Apatite" $3Ca_32PO_4,CaF_2$. In bone-earth or bone-phosphate. As a white powder precipitated with $2H_2O$. $Ca_32PO_4+2H_2SO_4=2CaSO_4+CaH_42PO_4$. [CALCIUM OXALATE $\mathbf{CaC_2O_4,2H_2O}$, a white powder. So insoluble, used for estimating CaO. By heat into $CaCO_3$. TARTRATE $\mathbf{CaC_4H_4O_6}$, white, insoluble. In making TARTARIC ACID $H_2C_4H_4O_6$]. SODIUM CALCIUM BORATE [$\mathbf{2(NaCa3BO_2)3B_2O_3,18H_2O}$], native at Iquique, Peru.

CALCIUM is precipitated quantitatively as OXALATE, and weighed as $\mathbf{CaCO_3}$, which contains **56** per cent. of **CaO**.

3. The metals magnesium, zinc, and cadmium.

This group of **dyad** metals forms many isomorphous salts. The metals are volatile and combustible. Each metal has but one basic oxide.

IX. Magnesium Mg = 24.

9. MAGNESIUM **Mg = 24**. A silver-white, malleable, and ductile metal, becoming slowly oxydized in damp air. Sp. gr. 1.743. Fusible at a red-heat and volatile. When heated in air, it burns with magnificent white light to MAGNESIUM OXIDE

MgO. In HCl it readily dissolves. **Mg** + 2HCl = H_2 + **$MgCl_2$**. Also readily soluble in NH_4Cl. *Prep.* of **Mg**. 1. From **$MgCl_2$** + Na_2 = 2NaCl + **Mg**. 2. By electrolysis from the fused CHLORIDE: **Mg** at the zincode. **One oxide**: powerfully **basic**. MAGNESIUM OXIDE **MgO** = 40. White, infusible, barely soluble, as: HYDRATE **MgH_2O_2**, requiring 5142 parts of water for solution. Precipitated from its salts by all hydrates of alkalies and alkaline earths. SULPHIDE **MgS**, sparingly soluble. NITRIDE **Mg_3N_2** is crystalline. **Salts: soluble in water.** MAGNESIUM CHLORIDE, **$MgCl_2$**, white deliquescent mass. Used in making Mg. In prisms as **$MgCl_2,6H_2O$**. OXY-CHLORIDE **$MgO,MgCl_2$**. **Sulphate $MgSO_4,7H_2O$**. "Epsom salts." Right rhombic prisms, soluble in 3 of cold and 1½ of boiling water. Nauseous taste. In sea and other waters. Springs at Epsom. *Prep.* From sea-water by CaH_2O_2. Or from dolomite by H_2SO_4. NITRATE **$Mg2NO_3$, $6H_2O$**, deliquescent prisms. **Insoluble salts. Carbonate $MgCO_3$**. White mineral, known as "Magnesite." From a solution in CO_2, as $MgCO_3,3H_2O$. Magnesia alba is BASIC CARBONATE **$MgH_2O_2.2(MgCO_3,H_2O)$**. "Dolomite" is a **calcium-magnesium carbonate $CaMg2CO_3$**. A valuable building-stone. MAGNESIUM HYDROGEN PHOSPHATE **$MgHPO_4,7H_2O$**, in minute needles. AMMONIUM MAGNESIUM PHOSPHATE **$NH_4MgPO_4,6H_2O$**. Known as "Triple phosphate." Insoluble in ammonic hydrate. By heat into: PYRO-PHOSPHATE **$Mg_2P_2O_7$**, containing **36.21** per cent. of **MgO**. MgO estimated as such. [**Silicates**: important minerals. **Ortho-silicate** [**$2(MgFe)O,SiO_2$**], native as "Olivine" or chrysolite. **Meta-silicate** [**$2(MgO,SiO_2),H_2O$**] is "Picrosmine." "Talc" **$4MgO,5SiO_2$**. "Steatite" or "Soap-stone" **$3MgO,4SiO_2$**. "Meerschaum" **$2MgO,3SiO_2.4H_2O$**. "Serpentine" (**$2[(MgFe)O,SiO_2]$ MgH_2O_2,H_2O**. CALCIUM-MAGNESIUM SILICATE **$(CaMg)O,SiO_2$** is found as "Pyroxene" or "Augite." MnO and FeO often substitute MgO and CaO.]

X. Zinc Zn = 65.

10. ZINC **Zn = 65**. Bluish-white lustrous metal, very hard. Sp. gr. 6.8 to 7.1. Melts at 412°C., volatizes at bright-red heat. Boils at 1040°C. Brittle, but malleable between 100°C. and 150°C. Oxydizes very slowly in air, hence used for coating sheet-iron. Burns with blue flame to ZINC-OXIDE ZnO. Used in batteries as the "generating" or "positive" plate. Dissolved by acids. **Zn** + H_2SO_4,H_2O = H_2O + H_2 + **$ZnSO_4$**. **Zn** + 2HCl = H_2 + **$ZnCl_2$**. **3Zn** + 8**HNO_3** = $4H_2O$ + 2NO + 3**$Zn2NO_3$**. **One oxide: basic.** ZINC OXIDE **ZnO**, white, flocculent powder. Canary-yellow whilst red-hot. "Tutty" is impure ZnO. Used as paint. Isomorphous with MgO. Its HYDRATE **ZnH_2O_2**, white, gelatinous, and soluble in NH_3 and in KHO. **Zinc sul-**

phide ZnS. Native as "Blende," an ore of zinc. In rhombic dodecahedra. Its hydrate is white, insoluble in KHO: not precipitated by H_2S in acid solutions of Zn salts. **Metallurgy.** When roasted, into **ZnO** + SO_2. Then reduced with charcoal. **ZnO** + C = CO + **Zn.** **Salts: soluble in water.** CHLORIDE **$ZnCl_2$.** White, deliquescent, fusible at 100°C. Solution forms "Burnett's disinfecting fluid." ACETATE **$Zn2C_2H_3O_2,3H_2O$,** used in calico-printing. **Insoluble salts. Carbonate $ZnCO_3$.** Native as "Calamine" the most valuable ore of zinc. White, when pure. **Metallurgy.** By roasting: **$ZnCO_3$** = CO_2 + **ZnO.** With charcoal, **ZnO** + C = CO + **Zn.** Precipitated as: 8ZnO, $3CO_2$,$6H_2O$. **Silicate $2ZnO,SiO_2,H_2O$** is found as "Electric calamine." Zinc is best weighed as **ZnO,** 100 parts contain 80.24 of **zinc.**

XI. Cadmium Cd = 56.

11. CADMIUM **Cd = 56.** Tin-white metal, malleable, ductile, tenaceous. Melts at 227.8°C.; boils at 860°C. More volatile than zinc, the ores of which it often accompanies. Burns at a red-heat, forming a brown OXIDE **CdO.** Acids act as upon Zn. **One Oxide.** CADMIUM OXIDE **CdO.** Brown. HYDRATE **CdH_2O_2,** white, soluble in NH_3. **Cadmium sulphide CdS,** native as "Greenockite," in 6-sided prisms. Its hydrate, yellow, and precipitated in acid solutions of cadmium salts by H_2S, and thus separated from zinc. The metal obtained by roasting CdS and reducing with charcoal. **Salts: soluble.** CHLORIDE **$CdCl_2,2H_2O$,** 4-sided prisms. IODIDE **CdI_2** in pearly scales; used for iodizing collodion. NITRATE **$Cd2NO_3$.** SULPHATE **$CdSO_4,4H_2O$,** very soluble. **Insoluble salts.** CARBONATE **$CdCO_3$** white.

4. The Aluminum Group. Includes:

Aluminum, iron, manganesium, and **chromium.** Their **oxides Al_2O_3,Fe_2O_3,Mn_2O_3,** and **Cr_2O_3** are isomorphous, insoluble in water, and form a class of salts characterized as "ALUMS." The metals are rather HEXADS than TRIADS. Iron and manganesium are DYADS in their chief basic oxides **FeO** and **MnO.**

XII. Aluminum Al = 27.5.

12. ALUMINUM **Al = 27.5.** White, malleable, ductile. Very sonorous metal. Sp. gr. 2.5 to 2.67. Fuses at about 450°C. Burns with bluish-white light in oxygen to: OXIDE **Al_2O_3.** Dissolved by HCl. **2Al** + **6HCl** = $3H_2$ + **Al_2Cl_6.** Also by potassium hydrate. Unchangeable in pure air. Cu_2Al is "Aluminum bronze." *Prep.* of **Al.** *a.* By electrolysis of fused NaCl,**$AlCl_3$.** *b.* 2(NaCl,**$AlCl_3$**)+$3Na_2$=8NaCl+2**Al.** *c.* From

$2(3NaF,AlF_3) + 3Na_2 = 12NaF + 2Al$. **One basic oxide. Aluminum oxide Al_2O_3.** Found native as "corundum," in 6-sided prisms: "emery" is pounded corundum. "Sapphire" and "ruby" consist of Al_2O_3 tinted. Pure alumina is white, and fusible in oxy-hydrogen. Insoluble in water and in acids after strong ignition. HYDRATE $Al_2H_6O_6$, white, gelatinous, soluble in KHO. Al_2O_3 is the basis of "clay." MAGNESIUM ALUMINATE MgO,Al_2O_3, constitutes "Spinelle ruby." ZINC ALUMINATE ZnO,Al_2O_3, is "Gahnite." "Bauxite" is hydrated aluminum-ferric oxide. SULPHIDE Al_2S_3. By burning Al_2 in the vapour of S. N.B. From solutions of salts, Al is precipitated by NH_4HS as HYDRATE $Al_2H_6O_6$, white and soluble in KHO. **Salts: soluble.** ALUMINUM CHLORIDE Al_2Cl_6, yellow sublimate, volatile. $Al_2O_3 + 3C + 3Cl_2 = 3CO + Al_2Cl_6$. Also in crystals $Al_2Cl_6,12H_2O$. SODIUM ALUMINATE Na_2AlO_2, white compound, very soluble. ALUMINUM SULPHATE $Al_2SO_4,18H_2O$, in thin scales, soluble in two of water. Made by dissolving Al_2O_3 from clay in H_2SO_4. POTASSIUM ALUMINUM SULPHATE $KAlSO_4,12H_2O$, in octohedra and in cubes, soluble in 18 of cold and 2 of boiling water. Loses $5H_2O$ at 100°C., and other $5H_2O$ at 120°C., and the rest at 200°C.; *alumen ustum.* "Common alum." $NaAlSO_4,12H_2O$ and $NH_4AlSO_4,12H_2O$, are isomorphous. Alums are used in dyeing. **Insoluble salts. Aluminum fluoride Al_2F_6.** Native as "Cryolite" $3NaF,AlF_3$ in Greenland: contains 13 per cent. of aluminum. MELLITATE $Al_2C_4O_4$, found native in yellow octohedra, as mellite in lignite. [The "topaz" is $[2(Al_2O_3,SiO_2),Al_2O_3,SiF_4]$. ORTHO-PHOSPHATE $AlPO_4$. The "turquoise" is $2Al_2O_3,P_2O_5,5H_2O$. "Wavellite" $3(4Al_2O_3,3P_2O_5,18H_2O)Al_2F_6$. "Lazulite" $[2(3[CaMgFe]O,P_2O_5),(4Al_2O_3,3P_2O_5)6H_2O]$, coloured by "Vivianite.] "**Clay**" is an **aluminum silicate $Al_2O_3,2SiO_2,2H_2O$.** ["Cyanite" or "disthene" Al_2O_3,SiO_2. Among the "felspars" we have: "ortho-clase" or "adularia" $K_2O,Al_2O_3,6SiO_2$; "albite," $Na_2O,Al_2O_3,6SiO_2$; "Labradorite" $CaO,Al_2O_3,6SiO_2$, and "petalite" $L_2O,Al_2O_3,6SiO_2$. "Pumice-stone" is altered felspar. "Obsidian" is fused pumice. "Granite" is a mixture of quartz, felspar, and mica. Syenite contains "hornblende" instead of mica. "Uniaxal mica" $[4(MgKFe)O,(AlFe)_2O_3,4SiO_2.]$ "Biaxal-mica" $[(KFe)O,3(AlFe)_2O_3,6SiO_2.]$ "Hornblende" $[5(MgCaFeMn)O,6SiO_2.x(KCa)F_2.]$ Asbestos is a variety of "Amphibole" or hornblende. "Chlorite" $[4(MgFe)O,(AlFe)_2O_3,2SiO_2,3H_2O.]$ Among "zeolites" we have: "Analcime" $Na_2O,Al_2O_3,4SiO_2,2H_2O$; "Stilbite" $CaO,Al_2O_3,6SiO_2,6H_2O$; "Prehnite" $2CaO,Al_2O_3,3SiO_2,H_2O$. ULTRAMARINE is $2Al_2O_3,3SiO_2Al_2O_34SiO_2,Na_2S_2O_3,3Na_2S$].

XIII. Ferrum Fe = 56.

13. FERRUM **Fe** = **56**. Very rarely native, in meteorites. Almost silver-white when pure, of sp. gr. 7.844. The most tenaceous of metals. Most magnetic. Unchanged in dry air, and in water free from air and CO_2. Rusts in damp air. Burns in oxygen to FERROUS FERRIC OXIDE $\mathbf{Fe_3O_4}$. Melts at 1530°C. Decomposes H_2O at a red-heat: $3\mathbf{Fe} + 4H_2\mathbf{O} = 4H_2 + \mathbf{Fe_3O_4}$. Rendered passive by HNO_3. Dissolved by dilute HNO_3, either as $Fe2NO_3$ or Fe_3NO_3. By 2HCl. $\mathbf{Fe} + 2\mathbf{HCl} = H_2 + \mathbf{FeCl_2}$. By H_2,SO_4. $\mathbf{Fe} + H_2\mathbf{SO_4},H_2O = H_2O + H_2 + \mathbf{FeSO_4}$. "Meteorites" contain, in addition to iron, nickel and cobalt together with a little copper, manganesium, chromium, tin, magnesium, carbon, sulphur, and phosphorus. *Bar-iron* contains from 0.2 to 0.4 per cent. of carbon; sp. gr. 7.7. When strongly heated it softens, and can be "welded" by hammering. **Ores of iron.** "Magnetite" $\mathbf{FeO,Fe_2O_3}$ or $\mathbf{Fe_3O_4}$, in octohedra and massive. Gives the purest iron. "Specular iron-ore" $\mathbf{Fe_2O_3}$ in rhomboids, from Elba and Formosa. Reduced by charcoal. $\mathbf{Fe_2O_3} + 3C = 3CO + 2\mathbf{Fe}$. "Red haematite" $\mathbf{Fe_2O_3}$, massive and fibrous. "Brown haematite" $\mathbf{2Fe_2O_3,3H_2O}$, both fibrous and compact. Soluble in HCl. When roasted, it loses water and is easily reduced by fuel. "Spathic iron ore" $\mathbf{FeCO_3}$, in yellowish lenticular crystals, or massive. By roasting: $4FeCO_3 + O_2 = 4CO_2 + 2\mathbf{Fe_2O_3}$. And then reduced by heating with C. "Clay-ironstone" is an impure ferrous carbonate, mixed with clay, limestone, &c. The chief ore of Great Britain. Reduced in the *blast-furnace*. Roasted: lime added to unite with the silica of the ore to CALCIUM ORTHO-SILICATE Ca_2SiO_4 or "slag," and coal to reduce. The "slags" also contain other metals; $[12(CaMg\ MnFe)O],2Al_2O_3,9SiO_2$. *Cast iron* varies much. Sometimes Fe_4C, with Si from 0.25 to 3.5 per cent. Three kinds of cast iron: grey, mottled, and white. In white, all the carbon is combined. It is the most fusible. The mottled is coarse-grained, and contains visible points of graphite. The grey is soft and more fusible than the mottled; when heated and suddenly cooled, used for making chilled shot. *Refining.* Carbon burnt off and Si got rid of as Fe_2SiO_4. *Puddling* removes yet more C and Si. ALLOYS. STEEL contains from 0.7 to 1.7 per cent. of carbon. In cementation process, iron unites with 1.5 per cent. of C. [SILICIDE Fe_2Si. NITRIDES Fe_2N. Fe_3N and Fe_3N_2.] **Oxides: two basic,** besides an intermediate oxide and an acid. 1. FERROUS OXIDE **FeO**, very unstable *per se;* black. HYDRATE $\mathbf{FeH_2O_2}$, white, unstable, passing by oxydation through green, dark-green, and red-brown to ferric hydrate. FERROUS SALTS. 2. **Ferric oxide** $\mathbf{Fe_2O_3}$, red-brown. "Bloodstone" is a

variety of Fe_2O_3. Its HYDRATE $\mathbf{2Fe_2O_3,3H_2O}$, red-brown, bulky. FERRIC SALTS. 3. **Ferrous-ferric oxide $\mathbf{Fe_3O_4}$**, is black; its HYDRATE $\mathbf{Fe_3O_4,H_2O}$ is also black. 4. FERRIC ACID $\mathbf{H_2FeO_4}$, is only known in combination. $\mathbf{K_2FeO_4}$, forms an amethystine-coloured solution. *Prep.* By passing Cl_2 through ferric hydrate suspended in a solution of KHO. SULPHIDES. FERROUS SULPHIDE **FeS**, reddish-brown. Either by direct union of the elements or by heating $FeS_2 + Fe = 2FeS$. Used in making H_2S. $FeS + 2HCl = FeCl_2 + H_2S$. Ferrous salts precipitated as black hydrate FeS,H_2O by NH_4HS. **Di-sulphide $\mathbf{FeS_2}$.** "Iron-pyrites" or "Mundic;" in cubes of brassy lustre. By roasting $4FeS_2 + 11O_2 = 8SO_2 + 2Fe_2O_3$. Heated in absence of air: $3FeS_2 = Fe_3S_4 + S_2$. FERROUS FERRIC SULPHIDE $\mathbf{Fe_3S_4}$, magnetic. Another variety $\mathbf{Fe_3S_8}$ is soluble in HCl. SULPH-ARSENIDE **FeSAs**. PHOSPHIDE $\mathbf{Fe_2P}$, hard and brittle. Makes iron "cold short." **1. Soluble ferrous salts.** FERROUS CHLORIDE $\mathbf{FeCl_2}$, white. In crystals $\mathbf{FeCl_2,4H_2O}$. IODIDE $\mathbf{FeI_2,4H_2O}$ in green crystals. By direct union of the elements. Used in making KI. $FeI_2 + K_2CO_3 = FeCO_3 + 2KI$. NITRATE $\mathbf{Fe2NO_3,6H_2O}$, in pale-green rhomboids. [ACETATE $\mathbf{Fe2C_2H_3O_2,H_2O}$, in silken needles.] SULPHATE, $\mathbf{FeSO_4,7H_2O}$. In sea-green rhomboids, soluble in 2 of cold water. Green vitriol. Its solution absorbs O. $20FeSO_4 + 5O_2 + 6H_2O = 6Fe_23SO_4 + 2(2Fe_2O_3,SO_3,3H_2O)$. Becomes red-brown on exposure: hence "copperas;" it loses water, and by further heat: $2FeSO_4 = Fe_2O_3 + SO_2 + SO_3$. A good reducing agent: $6FeSO_4 + 2AuCl_3 = Fe_2Cl_6 + 2Fe_23SO_4 + 2Au$. BI CARBONATE $\mathbf{FeCO_3,CO_2}$, in chalybeate waters. Absorb oxygen, and deposit ferric hydrate. **2. Insoluble ferrous salts. Ferrous carbonate $\mathbf{FeCO_3}$.** White. Most abundant ore. Precipitated as greenish hydrate by an alkaline carbonate. OXALATE $\mathbf{2FeC_2O_4,3H_2O}$, yellow crystalline powder. HYDROGEN PHOSPHATE $\mathbf{FeHPO_4}$, white; becomes blue. ORTHO-SILICATE $\mathbf{Fe_2SiO_4}$, is finery-slag. FERROUS FERRICYANIDE $\mathbf{Fe_3Fdcy_2,3H_2O}$. **1. Ferric salts: soluble.** FERRIC CHLORIDE $\mathbf{Fe_2Cl_6}$, in brown scales. $Fe_2Cl_6,6H_2O$, in red deliquescent crystals. FERRIC IODIDE $\mathbf{Fe_2I_6}$. FERRIC SULPHATE $\mathbf{Fe_23SO_4}$, yellowish-white, deliquescent. "Coquimbite" $Fe_23SO_4,9H_2O$, a silky, white mineral. Forms ALUMS: $\mathbf{KFe2SO_4,12H_2O}$; $\mathbf{NaFe2SO_4,12H_2O}$ and $\mathbf{NH_4FeSO_4\ 12H_2O}$; are isomorphous, with the corresponding Al alums. FERRIC NITRATE $\mathbf{Fe3NO_3,xH_2O}$. POTASSIUM FERRIC TARTRATE $\mathbf{KFeOC_4H_4O_6}$. AMMONIUM FERRIC TARTRATE $\mathbf{NH_4FeOC_4H_4O_6,2H_2O}$. FERRIC ACETATE $\mathbf{Fe3C_2H_3O_2}$, is deep red. **2. Insoluble.** BASIC FERRIC SULPHATE $\mathbf{2Fe_2O_3,SO_3,3H_2O}$, is deposited from a solution of green vitriol. FERRIC PHOSPHATE $\mathbf{FePO_4,2H_2O}$, is white and insoluble in ACETIC ACID $HC_2H_3O_2$. "Vivianite" $FeHPO_4$, $2FePO_4,8H_2O$, a blue mineral. FERRIC OXALATE $\mathbf{Fe_23C_2O_4}$, is lemon-yellow. "Prussian blue" $\mathbf{Fe_43Fcy,18H_2O}$. Iron is esti-

mated as FERRIC OXIDE Fe_2O_3, containing 70 per cent. of metal. A ferrous, easily changed into a ferric salt, by nitric acid. $6FeSO_4 + 2HNO_3 + 3H_2SO_4 = 2NO + 4H_2O + 3Fe_2(SO_4)_3$.

XIV. Manganesium Mn = 55.

14. MANGANESIUM **Mn = 55**. Greyish-white, brittle metal. Magnetic. Sp. gr. 7 to 8. Slowly decomposes water. *Prep.* By heating $MnCO_3$, to whiteness with charcoal, in a smith's forge. **Oxides:** TWO basic oxides, TWO indifferent oxides **and two acids.** 1. MANGANOUS OXIDE **MnO**, is olive-green. Absorbs O from the air. By heating $MnCO_3$ in a stream of H, to keep off the air. $MnCO_3 = CO_2 + MnO$. HYDRATE MnH_2O_2 white, soluble in NH_3. Rapidly changes to brown manganic hydrate. Salts pink or rose-red. Strong base, isomorphous with MgO,ZnO,FeO. 2. **Manganic oxide Mn_2O_3**, native as "Braunite;" also as "Manganite" Mn_2O_3,H_2O in brilliant right-rhombic prisms. Very feeble base: salts red. Isomorphous with Al_2O_3 and Fe_2O_3. Gives a violet colour to glass, and a red colour to the amethyst. 3. **Manganous-manganic oxide Mn_3O_4**, occurs native in "Hausmannite" in black 4-sided prisms. Obtained by igniting either MnO, or $MnCO_3$ or Mn_2O_3. Not basic. 4. **Manganesium peroxide MnO_2**, constitutes "Pyrolusite," *the* ore of manganesium. In steel-grey rhombic prisms. "Varvicite" is $Mn_2O_3,2MnO_2.H_2O$. Much used in the arts. With HCl, gives Cl_2. $4HCl + MnO_2 = 2H_2O + MnCl_2 + Cl_2$. Heated it gives off O_2. $3MnO_2 = Mn_3O_4 + O_2$. With sulphuric acid: $2MnO_2 + 2H_2SO_4 = 2MnSO_4 + 2H_2O + O_2$. 5. MANGANIC ACID H_2MnO_4, is green, unstable. Di-basic and isomorphous with H_2SO_4, H_2FeO_4, and H_2CrO_4. MANGANATES. K_2MnO_4, is "mineral chameleon." Condy's disinfectant is principally Na_2MnO_4. Solution readily decomposed by organic matters. 6. PERMANGANIC ACID $HMnO_4$, forms violet salts. POTASSIUM PERMANGANATE $KMnO_4$. in red needles. Is best prepared by decomposing K_2MnO_4 with CO_2. $3K_2MnO_4 + 2CO_2 = 2K_2CO_3 + MnO_2 + 2KMnO_4$. By decantation and evaporation. Also used by Condy in his invaluable preparations. **Sulphide MnS**, native as "Manganese blende." As HYDRATE of flesh-colour, when a manganous salt is precipitated by NH_4HS; becomes brown by oxydation. 1. **Manganous salts: soluble in water.** CHLORIDE $MnCl_2,4H_2O$, in tables of pink hue, very deliquescent. Purified from Fe_2Cl_6 in the residues of Cl_2 manufacture, by boiling with $MnCO_3$ or with MnS,H_2O; Mn takes the place of Fe in solution. SULPHATE $MnSO_4,7H_2O$, in prisms at 5° C; otherwise $MnSO_4,5H_2O$. ACETATE $Mn2C_2H_3O_2$, used in calico-printing. 2. **Insoluble salts.** **Manganous carbonate $MnCO_3$**, native as "Manganese spar" of pink hue, isomorphous with $FeCO_3$. Precipitated as: $2MnCO_3,H_2O$. PHOSPHATE $MnHPO_4$.

white powder. BORATE **$Mn2BO_2$**, white. OXALATE **$MnC_2O_4,2H_2O$**, white. FERROCYANIDE **$Mn_2FeC_6N_6$**, aq., white. FERRICYANIDE **$Mn_2 2FeC_6N_6$**, brown. **Manganic salts: soluble.** MANGANIC CHLORIDE **Mn_2Cl_6**, dark brown. By heat into $2MnCl_2+Cl_2$. SULPHATE **$Mn_2 3SO_4$**, forms with K_2SO_4, MANGANESE ALUM **$KMn2SO_4$, $12H_2O$**, isomorphous with **$KAl2SO_4,12H_2O$** and **$KFe2SO_4,12H_2O$**.

XIV. Chromium Cr = 52.5.

14. CHROMIUM **Cr = 52.5.** Steel-grey metal, less fusible than Pt. Discovered by Vauquelin in 1797. Sp. gr. 6.81. Insoluble even in aqua regia. *Prep.* By strong ignition of CHROMIC OXIDE Cr_2O_3 with charcoal; or by passing the vapour of Na_2 over heated Cr_2Cl_6. $2Cr_2Cl_6 + 3Na_2 = 6NaCl + 2Cr$. **Oxides: two** basic oxides and **one** intermediate oxide: **one** anhydride and **two acids.** CrO. Cr_2O_3. Cr_3O_4. CrO_3. H_2CrO_4. $HCrO_4$. 1. CHROMOUS OXIDE **CrO** only known as a brown HYDRATE, which absorbs oxygen and becomes HYDRATE OF CHROMOUS CHROMIC OXIDE **Cr_3O_4,H_2O**. 2. CHROMIC OXIDE **Cr_2O_3**, green, isomorphous with **Mn_2O_3**, **Al_2O_3**, and **Fe_2O_3**. HYDRATE **$Cr_2O_3,7H_2O$**, bluish-green, precipitated by NH_3. Two classes of chromic salts. Green, and uncrystallizable; violet and crystallizable. Cr_2O_3 gives a green colour to glass. It is the colouring matter of the emerald, chlorite, pyrope, serpentine, &c. *Prep.* of **Cr_2O_3**. By heating AMMONIUM CHROMATE **$(NH_4)_2CrO_4$**. Also by igniting a mixture of $K_2Cr_2O_7$ with starch. "Chrome-iron-ore" **FeO,Cr_2O_3**, is the ore of chromium; in octohedra like FeO,Fe_2O_3 and also massive. 3. CHROMIC ANHYDRIDE **CrO_3**, in brilliant, dark crimson, deliquescent prisms. It fuses at 200° C., and looks black. By a greater heat into Cr_2O_3 and O_2. From $CrF_6 + 3H_2O = 6HF + CrO_3$. 4. CHROMIC ACID **$H_2CrO_4$**, in CHROMATES. Alkaline chromates soluble in water. **$K_2Cr_2O_7$**, in red, 4-sided tables, soluble in 10 of water. By heat into K_2CrO_4 and oxygen. **K_2CrO_4**, in yellow prisms, isomorphous with K_2SO_4. POTASSIUM DICHROMATE $K_2Cr_2O_7$, is made, by strongly heating FeO,Cr_2O_3 with a mixture of chalk and K_2CO_3. Digested in water, K_2CrO_4 dissolves, and is changed into $K_2Cr_2O_7$ by HNO_3. 5. PERCHROMIC ACID **$HCrO_4$**, is violet-coloured and most unstable. Formed by addition of H_2O_2 to a solution of H_2CrO_4. CHROMIC SULPHIDE **Cr_2S_3**, black, shiny scales. N.B. On addition of NH_4HS to a chromic salt, CHROME-HYDRATE $Cr_2O_3,7H_2O$, of bluish-green colour is precipitated, soluble with green colour in KHO. CHROMIUM NITRIDE **Cr_2N_4**, chocolate-brown. **Chromic oxide salts: soluble. Chromic chloride Cr_2Cl_6**, pale violet-coloured scales. Volatile. *Prep.* $2Cr_2O_3 + 3C + 3Cl_2 = 3CO + Cr_2Cl_6$. [CHLORO-CHROMIC ACID **$CrCl_2O_2$** dense red liquid, decomposed by water ($2H_2O$) into: H_2CrO_4 and 2HCl. *Prep.* By distilling NaCl with $K_2Cr_2O_7$

and H_2SO_4. CHROMIUM HEXA-FLUORIDE **CrF_6**, a blood-red liquid. By $4H_2O = 6HF + H_2CrO_4$.] CHROMIC SULPHATE **$Cr_2 3SO_4, 5H_2O$**, green, uncrystallizable. $Cr_2 3SO_4, 15H_2O$, violet-coloured and crystallizable. CHROME-ALUM **$KCr2SO_4, 12H_2O$** amethystine; isomorphous with **$KAl2SO_4.12H_2O$**; **$KFeSO_4, 12H_2O$**, and **$KMnSO_4$, $12H_2O$**. NITRATE **$Cr3NO_3$**, green salt. POTASSIUM CHROMIUM OXALATE **$K_2Cr3C_2O_4, 3H_2O$**, is blue. **$KCr2C_2O_4, 4H_2O$** is red. **Insoluble chromic salts.** ANHYDROUS SULPHATE **$Cr_2 3SO_4$**, is red. OXALATE **$Cr_2 3C_2O_4$**, is green.

CHROMIUM is best estimated as **Cr_2O_3**, which contains 68.63 per cent. of **Cr**.

5. Cobalt and nickel with glucinum, yttrium, erbium, cerium, lanthanum, didymium. Thorinum and uranium included.

The chief oxides of this group are protoxides. In fact, they are the only ones of importance. Cobalt and nickel are magnetic. Uranium included for convenience: its chief oxide is uranic oxide U_2O_3.

XVI. Cobalt Co = 59.

16. COBALT **Co = 59**. Reddish-white, brittle metal, discovered by Brandt in 1733. Sp. gr. 8.95. Fusible in a wind-furnace. Magnetic. Very tenacious. Slowly dissolved by HCl and H_2SO_4, H_2O; readily by HNO_3. *Prep.* From CoC_2O_4, in the forge-heat. **Cobalt di-arsenide $CoAs_2$**, is "tin-white cobalt," or "speiss cobalt;" the best ore. **Cobalt sulph-arsenide CoSAs**, in cubes, dodecahedra, and octohedra, known as "cobalt-glance." **Oxides. 2 basic oxides** and **one** intermediate. COBALTOUS OXIDE **CoO**, greenish-grey. Strongly basic. Isomorphous with ZnO, MgO, FeO. By roasting, it absorbs O and becomes Co_3O_4. COBALTOUS HYDRATE **CoH_2O_2**, is rose-coloured, readily soluble in NH_4HCO_3. Salts blue or pink. "Zaffre" is an impure oxide. "Smalt" is a glass, coloured blue by cobaltous oxide. The ore is roasted, so as to oxydize the Co, but to leave the associated Ni, Fe, and Cu combined with As and S; it is then slowly melted with quartz SiO_2, and K_2CO_3. CoO unites with the potassium silicate and forms the blue glass called *Smalt*. The so-called *speiss* at the bottom of the crucible contains sulphide and arsenides of Ni, Fe, and Cu. 2. COBALTIC OXIDE **Co_2O_3**; black. By suspending CoH_2O_2 in solution of KHO, and passing Cl_2 through. Thus: $2CoH_2O_2 + 2KHO + Cl_2 = (Co_2O_3, 3H_2O) + 2KCl$. By heat into Co_3O_4. Salts gradually pass into cobaltous. Of no importance. COBALTOUS SULPHIDE **CoS**, is black. HYDRATE **CoS, H_2O**, also black. By precipitation of a cobaltous salt by NH_4HS. COBALTIC SULPHIDE **Co_2S_3**. COBALT PER-SULPHIDE **CoS_2**. **Cobaltous salts: soluble.** CHLORIDE **$CoCl_2, 6H_2O$**, in ruby-red octohedra.

POTASSIUM COBALTICYANIDE **K_3CoCy_6**, in yellow prisms. NITRATE **$Co2NO_3,6H_2O$**, deliquescent red mass. ACETATE **$Co2C_2H_3O_2$**. **Insoluble salts.** CARBONATE **$3CoCO_3.2H_2O$**. BASIC CARBONATES **$3CoO,2CoCO_3,4H_2O$**, is red; precipitated from a hot solution. **Arsenate $Co_3 2AsO_4,8H_2O$**, is "cobalt-bloom." COBALT FERRO-CYANIDE **Co_2FeCy_6**, yellowish-green. COBALT FERRICYANIDE **$Co_3 2Cfdy$**, dark reddish-brown. **Cobalt** is estimated in the metallic form, and as **Co_3O_4**, corresponding to 73.44 per cent. of metal.

XVII. Nickel Ni = 59.

17. NICKEL **Ni = 59**. Hard, lustrous, white, tenacious metal of sp. gr. 8.82. Fusible in wind-furnace. Magnetic. Readily into NICKELOUS NITRATE, $Ni2NO_3$ by HNO_3. *Prep.* From NiC_2O_4 in a wind-furnace. Much used in making GERMAN SILVER $Zn_3Ni_2Cu_3$. The chief ORES are: **Nickel arsenide NiAs**, or "Kupfernickel." **Nickel di-arsenide $NiAs_2$**, or "arsenical nickel." **Nickel sulph-arsenide NiSAs** or "nickel-glance." Cobalt and nickel are separated by adding an excess of HCy to their mixed nitrates, and then pure KHO. After absorption of O from the air, the liquid becomes yellow and we have a mixture of POTASSIUM NICKEL CYANIDE $2KCy,NiCy_2$ and POTASSIUM COBALTICYANIDE K_3CoCy_6. If now boiled and $Hg2NO_3$ added, the nickel salt is alone decomposed and precipitated along with HgO and NiH_2O_2. $2KCy,NiCy_2+HgO+H_2O=2KCy,HgCy_2+NiH_2O_2$. **Oxides. One basic oxide, NiO, and one PEROXIDE Ni_2O_3.** NICKEL OXIDE **NiO**; olive-green. By heating the carbonate NICKEL HYDRATE NiH_2O_2, light-green, soluble with blue colour in NH_3. Salts green. PEROXIDE **Ni_2O_3**, black. AS HYDRATE **$Ni_2O_3.3H_2O$**, also black. Prepared like $Co_2O_3,3H_2O$. **Three sulphides.** NICKEL SULPHIDE **NiS**, in greyish-yellow capillary crystals as "millerite." Precipitated as black HYDRATE **NiS,H_2O** from nickel salts by NH_4HS. PERSULPHIDE **NiS_2**. SUBSULPHIDE **Ni_2S**. **Soluble nickel salts.** NICKEL CHLORIDE **$NiCl_2,9H_2O$**, in green crystals. NICKEL SULPHATE **$NiSO_4,7H_2O$**, green rhombic prisms, isomorphous with **$FeSO_4.7H_2O$**; **$ZnSO_4,7H_2O$**; **$MgSO_4,7H_2O$**. Soluble in 3 of water. NITRATE **$Ni2NO_3$**. ACETATE **$Ni2C_2H_3O_2$**. POTASSIUM NICKEL CYANIDE **$2KCy,NiCy_2,H_2O$**, in yellow oblique rhombic prisms. **Insoluble nickel salts.** CARBONATE **$3NiCO_3 2H_2O$**. BASIC CARBONATES. **$2NiO,2NiCO_3,7H_2O$**; and **$3NiO,2NiCO_3,4H_2O$**. NICKEL CYANIDE $NiCy_2$, apple-green. NICKEL FERRO-CYANIDE Ni_2FeCy_6. NICKEL FERRICYANIDE $Ni_3 2Fdcy$, yellowish-green.

Nickel is estimated as **NiO**, containing 78.67 per cent. of metal.

[XVIII. Glucinum G = 9.5.

18. BERYLLIUM or GLUCINUM **G = 9.5**. White, malleable metal of sp. gr. 2.1. Does not burn in air. Fusible at a bright-

red-heat. The metal is obtained from GLUCINUM CHLORIDE GCl_2 either by electrolysis, or by Na_2. **One basic oxide.** GLUCINUM OXIDE GO. White. Its **hydrate** is gelatinous like aluminum hydrate, soluble in the fixed alkalies, and in **ammonium carbonate**; thus it is separated from aluminum hydrate. It displaces NH_3 from ammonium salts and dissolves. **Salts.** Sweet taste, hence γλυκὺς. GLUCINUM CHLORIDE GCl_2, sublimes in white needles. Crystallizes as $GCl_2,4H_2O$. SULPHATE GSO_4, $4H_2O$, in octohedra. POTASSIUM GLUCINUM SULPHATE K_2SO_4,GSO_4, $2H_2O$. **Insoluble salts.** CARBONATE GCO_3. SILICATES. **Orthosilicate** G_2SiO_4, native as "phenakite." **Aluminum glucinum silicate** $3GO,Al_2O_3,6SiO_2$, constitutes the "emerald" or "beryl." If fused with K_2CO_3, decomposed by HCl and evaporated to dryness, SiO_2 is rendered insoluble. On re-solution in water, the two hydrates are precipitated by NH_3, and GH_2O_2 dissolved by NH_4HCO_3. **Glucinum aluminate** GO,Al_2O_3, is "chryso-beryl." G is weighed as GO.]

[XIX. Yttrium Y = 61.7.

19. YTTRIUM Y = 61.7. Resembles G. Burns brilliantly in O_2. The name given from Ytterby in Sweden, where "gadolinite," as Yttrium, Glucinum, Cerium, and Iron silicate is found. **One oxide: basic.** YTTRIUM OXIDE YO, is white and of sp. gr. 4.842. Its HYDRATE is soluble in alkaline carbonates, but NOT in the fixed alkalies. Salts colourless.]

[XX. Erbium E = 112.6?

20. ERBIUM E = 112.6? Its OXIDE EO forms salts of a rose-red colour. In a Bunsen burner, EO glows with a green light and furnishes a continuous spectrum crossed by brilliant streaks. Impure YO contains EO.]

[XXI. Cerium Ce = 92.

21. CERIUM Ce = 92. In "cerite," a hydrated basic silicate. **Two basic oxides.** CEROUS OXIDE CeO. CEROUS OXALATE CeC_2O_4, $3H_2O$, is used in medicine. Potassium cerous sulphate is insoluble in K_2SO_4. CERIC OXIDE Ce_2O_3, forms salts yellow and red.]

[XXII. Lanthanum La = 92.

22. LANTHANUM La = 92. Discovered by Mosander in 1841, hidden in cerium, hence λανθάνειν, "to lie hidden." Its OXIDE is buff-coloured, and forms colourless salts, precipitated by soluble oxalates.]

[XXIII. Didymium D = 96.

23. DIDYMIUM **D = 96.** But little known. Discovered by Mosander. Found with lanthanum; so called from δίδυμος, "twin." Its OXIDE is brown. HYDRATE insoluble in the alkalies. Salts pink, not precipitated by NH_4HS.]

[XXIV. Thorinum Th = 238.

24. THORINUM **Th = 238.** This metal resembles Zirconium. It burns with great brilliancy when strongly heated to THORINUM OXIDE ThO_2. Its hydrate is soluble in solutions of the carbonates, but not of the alkalies. ThO_2 is of sp. gr. 9.4. It is found in the mineral "thorite." **Salts.** THORINUM CHLORIDE $ThCl_4$, is volatile. Used in making the metal $ThO_2 + 2C + 2Cl_2 = 2CO + 2ThCl_4$. Then $ThCl_4 + 2Na_2 = 4NaCl + Th$. POTASSIUM THORIUM SULPHATE $2K_2SO_4,Th2SO_4,H_2O$, is precipitated by a solution of K_2SO_4.]

[XXV. Uranium U = 120.

25. URANIUM **U = 120.** Steel-grey, malleable metal. Sp. gr. 18.4. Burns brilliantly when heated. Dissolved by HCl and H_2SO_4. Presents some analogies with Fe and Mn, but is better treated separately. *Prep.* From URANOUS CHLORIDE UCl_2, when heated with K_2. **Two basic** and **two** intermediate **oxides.** UO and U_2O_3; UO,U_2O_3 and $2UO,U_2O_3$. 1. URANOUS OXIDE **UO.** By igniting the oxalate in closed vessels. Its hydrate reddish-brown; from UCl_2 by NH_3. Salts green. 2. URANIC OXIDE U_2O_3. Brick-red: by heating $U_2O_3,2H_2O$ to 300°C. Salts bright yellow. Precipitated by KHO, as POTASSIUM URANATE $K_2O,2U_2O_3$, of yellow colour. 3. URANOUS URANIC OXIDE UO,U_2O_3, is green. Obtained by igniting (4) **Di-uranous uranic oxide** $2UO,U_2O_3$. Called black oxide. Found native as "pitchblende," the chief ore of uranium. Prepared by igniting URANIC NITRATE $U_2O_2 2NO_5$, $6H_2O$. Gives a black colour to porcelain. **Salts.** URANOUS CHLORIDE UCl_2, green, deliquescent. Precipitated as black sulphide by NH_4HS. URANIC CHLORIDE U_2Cl_3, dark-brown needles. NH_4HS precipitates uranic salts, as yellowish-brown sulphide. **Calcium di-uranic phosphate** $Ca2U_2O_2,2PO_4,8H_2O$, a micaceous mineral called "uranite." **Cupric di-uranic phosphate** $Cu2U_2O_2$, $2PO_4,8H_2O$, native as "chalcolite."]

6. Thallium, silver, lead, mercury, copper and indium.

[XXVI. Thallium Tl = 204.

26. THALLIUM **Tl = 204.** This metal was discovered by Mr. Crookes in 1861, through the spectroscope. From θαλλός, "a budding twig," to indicate the green line in the spectrum.

Bluish-white metal, resembling lead; of sp. gr. 11.81 to 11.91. Sp. heat 0.03355; resembles silver. A MONAD metal. Soft and malleable. Oxydizes most readily. Melts at 293.9°C, and burns with green light. HNO_3 and $H_2SO_4,2H_2O$ dissolve it readily. Burns when heated in chlorine. *Prep.* From Tl_2SO_4 by means of Zn. **Three oxides; one basic.** 1. SUBOXIDE? 2. THALLIUM OXIDE $\mathbf{Tl_2O}$, yellow. Its hydrate in pale-yellow prisms, very soluble in H_2O. Solution alkaline and absorbs CO_2. Solution precipitates Mg, &c. PEROXIDE $\mathbf{Tl_2O_3}$, brown. THALLIUM SULPHIDE $\mathbf{Tl_2S}$, brownish-black, by NH_4HS. **Salts.** CHLORIDE $\mathbf{TlCl}$, yellowish-white, little soluble in water, less in NH_3. [Also: $TlCl_2$; Tl_2Cl_3 and $TlCl_3$.] NITRATE $\mathbf{TlNO_3}$, in prisms. SULPHATE $\mathbf{Tl_2SO_4}$, in 6-sided prisms. Forms a THALLIUM ALUM $\mathbf{TlAl2SO_4.12H_2O}$. CARBONATE $\mathbf{Tl_2CO_3}$ in flattened prisms, soluble in 25 of water. Salts poisonous.]

XXVII. Argentum or Silver Ag = 108.

27. ARGENTUM **Ag = 108.** Found native, both crystallized and massive. The whitest and most lustrous of the metals. Sp. gr. 10.53. Melts at 1023°C. Best conductor of heat and electricity. A *noble* metal: does not tarnish in pure air, and its oxide is reduced by heat alone. When melted absorbs O and "spits" on cooling. Great affinity for S. HNO_3 the great solvent. When slowly dissolved: $\mathbf{2Ag} + 3\mathbf{HNO_3} = H_2O + HNO_2 + 2\mathbf{AgNO_3}$. Boiled with H_2SO_4: $\mathbf{Ag} + 2H_2\mathbf{SO_4} = 2H_2O + SO_2 + \mathbf{AgSO_4}$. **Alloys.** Ag_3Cu_2. Silver coinage contains 7.5 per cent. of Cu; sp. gr. 10.3. ASSAYING OF CUPELLATION. English coin requires 5½ times its weight of lead for cupellation; the base metal oxydizes and is absorbed by the cupel. **Oxides. One basic** oxide; a **sub-oxide** and a **peroxide.** Ag_2O: Ag_4O and Ag_2O_2. SILVER SUBOXIDE $\mathbf{Ag_4O}$, very unstable. SILVER OXIDE $\mathbf{Ag_2O}$, brown. Hydrate also brown. Very soluble in NH_3. By heat into Ag and O_2. Forms salts. PEROXIDE $\mathbf{Ag_2O_2}$, in grey crystals, by electrolysis of $AgNO_3$. **Silver sulphide** $\mathbf{Ag_2S}$. Is found native as "silver-glance," both massive and in cubes, octohedra. The chief *ore* of silver. "Red silver ore" is $\mathbf{3Ag_2S,Sb_2S_3}$. Ag_2S, black, is precipitated by H_2S from silver-salts. **Metallurgy.** The ore at Freyberg contains Ag_2S, FeS_2, $FeCuS_2$. It is first roasted with NaCl. $\mathbf{Ag_2S} + 2\mathbf{NaCl} + 2O_2 = Na_2SO_4 + 2\mathbf{AgCl}$. $CuS + 2O_2 = CuSO_4$. $2CuS + 4NaCl + 4O_2 = 2Na_2SO_4 + Cl_2 + 2Cu_2Cl_2$. $2FeS_2 + 6NaCl + 7O_2 = 3Na_2SO_2 + Fe_2Cl_6 + SO_2$. The powder is next mixed with water in a revolving cask, mixed with scrap iron and after sufficient time to convert $Fe_2Cl_6 + Fe$ into $3FeCl_2$; $Cu_2Cl_2 + Fe = FeCl_2 + 2Cu$; $CuSO_4 + Fe = FeSO_4 + Cu$ and: $2\mathbf{AgCl} + Fe$ into $FeCl_2 + \mathbf{Ag}$, MERCURY is

added, and the amalgam formed with Ag and Cu, washed, strained, and heated: **Ag** with **Cu** remains. **Silver salts.** 1. **Soluble.** ARGENTUM NITRATE $AgNO_3$, in square tables, soluble in their own weight of water. Fuses at 219°C. "Lunar caustic." Reduced by heat. SULPHATE Ag_2SO_4, in small rhombic prisms, soluble in 90 of water. ACETATE $AgC_2H_3O_2$, thin silken needles, sparingly soluble in cold water. FLUORIDE **AgF**, very soluble. POTASSIUM ARGENTUM CYANIDE $2(KCy,AgCy),H_2O$ in rhombic prisms. Used in electro-plating. Soluble silver-salts are irritant poisons. NaCl, the best antidote. 2. **Insoluble salts. Argentum chloride AgCl**, native as "horn-silver." White, soluble in NH_3, insoluble in HNO_3. Soluble in NaCl. Fusible at 260°C. Reduced by Zn. $2AgCl + Zn = ZnCl_2 + 2Ag$. Also, by heat: $4AgCl + 2Na_2CO_3 = 4NaCl + O_2 + 2CO_2 + 4Ag$. **Bromide AgBr**, yellowish, soluble in KBr. Native as "Bromite." **Iodide AgI**, pale yellow, soluble in KI, insoluble in NH_3. Native as "Iodite." CYANIDE **AgCy**, white, soluble in NH_3. ORTHO-PHOSPHATE Ag_3PO_4, bright yellow. PYRO-PHOSPHATE $Ag_4P_2O_7$, white. METAPHOSPHATE $AgPO_3$, white. All phosphates soluble in NH_3 and in HNO_3. ARSENITE Ag_3AsO_3, yellow. ARSENATE Ag_3AsO_4, liver brown. Both soluble in NH_3 and HNO_3. BORATE $AgBO_2$, white, soluble in HNO_3. CHROMATE Ag_2CrO_4, dark crimson, soluble in HNO_3. TARTRATE $Ag_2C_4H_4O_6$, white. OXALATE $Ag_2C_2O_4$, white. FERROCYANIDE Ag_4FeCy_6, white. FERRICYANIDE Ag_3Fdcy, orange.

XXVIII. Plumbum or Lead Pb = 207.

28. PLUMBUM **Pb = 207.** Bluish-white metal, soft, malleable, and ductile. Fuses at 325°C; contracts on cooling. Tarnishes slowly in damp air. Acted upon by soft water in presence of air and CO_2. crystals of $PbH_2O_2,PbCO_3$ precipitated. Chlorides and nitrites also act upon lead. Readily oxydizes when heated. Nitric acid the chief solvent. $3Pb + 8HNO_3 = 4H_2O + 2NO + 3(Pb2NO_3)$. **Oxides: four,** only ONE of which BASIC. **Pb_2O; PbO; $2PbO,PbO_2$,** and **PbO_2.** 1. SUBOXIDE **Pb_2O**, black. 2. LEAD OXIDE **PbO**, yellow. "Litharge" is fused, "Massicot' unfused **PbO**. HYDRATE **$2PbO,H_2O$** is white and soluble in much KHO. Slightly soluble in water. Powerful base. 3. MINIUM **$2PbO,PbO_2$.** Also called "red lead," a pigment used as priming. By carefully heating laevigated lead-oxide in a reverberatory furnace at 320°C. Decomposed by nitric acid. 4. **Lead peroxide PbO_2,** puce-coloured. Native as "brown lead ore" in brilliant 6-sided prisms. *Prep.* From $2PbO,PbO_2$ by $4HNO_3 = 2(Pb2NO_3) + 2H_2O + PbO_2$. Also: $Pb2C_2H_3O_2 + Na_2CO_3 + Cl_2 + 2H_2O = 2NaCl + 2HC_2H_3O_2 + H_2O + CO_2 + PbO_2$. Absorbs SO_2. $PbO_2 + SO_2 = PbSO_4$. **Lead sulphide PbS**, black. Precipitated by

H_2S even in acid solutions. PbS is the chief **ore** of lead. As "galena" it is found massive, as well as in cubes and dodecahedra of leaden hue. **Metallurgy.** PbS is first roasted, and changed by oxydation partly into PbO and SO_2, and partly into $PbSO_4$. Thus: $2PbS + 3O_2 = 2SO_2 + 2PbO$. $PbS + 2O_2 = PbSO_4$. When mixed with unchanged PbS, the doors of the furnace being shut, lead is obtained. $2PbO + PbS = SO_2 + 3Pb$. $PbSO_4 + PbS = 2SO_2 + 2Pb$. **Alloys.** *See* **Tin. Salts of lead.** 1. **Soluble salts.** LEAD CHLORIDE $PbCl_2$, brilliant needles soluble in 135 parts of cold, and 33 of boiling water. NITRATE $Pb2NO_3$, in white octohedra, soluble in 8 of water. By heat: $2Pb2NO_3 = 2PbO + O_2 + 4NO_2$. ACETATE $Pb2C_2H_3O_2,3H_2O$, is the "sugar of lead" of commerce. Right rhombic prisms, soluble in 2 of water. BASIC ACETATE $2PbO,Pb2C_2H_3O_2$. Goulard's extract $2PbO,H_2O,Pb2C_2H_3O_2$. 2. **Insoluble. Oxy-chloride** $2PbO,PbCl_2$, native as "mendipite." Turner's yellow is $7PbO,PbCl_2$. CHLORO-SULPHIDE $3PbS,2PbCl_2$, is red. Obtained by incomplete decomposition of $PbCl_2$, by H_2S. BROMIDE $PbBr_2$, white, sparingly soluble. IODIDE PbI_2, yellow, soluble in much boiling water. $Pb_2OI_4,4PbCO_3$, is blue. CYANIDE $PbCy_2$, white. FERROCYANIDE Pb_2FeCy_6, white. Ferricyanide $Pb_3 2Cfdy$. **Sulphate** $PbSO_4$, white. Native as "lead vitriol" in white prisms and octohedra. Contained in oil of vitriol. **Chromate** $PbCrO_4$, native as "Lehmannite," in oblique prisms. Yellow powder when precipitated. DI-PLUMBIC CHROMATE $2PbO,CrO_3$, is scarlet. SULPHITE $PbSO_3$, white. **Carbonate** $PbCO_3$, native as "Cerussite" in needles. WHITE LEAD $PbH_2O_2,2PbCO_3$, is the common white paint. Soluble in HNO_3, as $Pb2NO_3$. Formed by the action of CO_2 upon $2PbO,Pb2C_2H_3O_2$. SILICATE Pb_2SiO_4. FLINT GLASS $K_2O,PbO,6SiO_2$. LEAD SILICATE and BORATE $3(PbOSiO_2)$, $3PbO,2B_2O_3$. *Paste* or *Strass* for imitating gems $K_2O,3PbO,8SiO_2$.

Lead salts are poisonous. The best antidote is Glauber salt, or Epsom salt. Lead is weighed as $PbSO_4$, containing 68.31 per cent. of metal.

XXIX. Quicksilver or Hydrargyrum Hg = 200.

29. HYDRARGYRUM **Hg = 200.** A metal rarely found native; fluid above −38°.8C., lustrous like Ag, and of sp. gr. 13.596. It boils at 350°C. Does not tarnish in air, and its oxide is reduced by heat alone; therefore a noble metal like Ag, Au, and Pt. Its name from ὕδωρ, "water," and ἄργυρον. Forms AMALGAMS with the metals. AgHg. CuHg. CuFe. Zn_2Hg. Pb_2Hg. Sn_7Hg. Dissolved by H_2SO_4 when heated: $Hg + 2H_2SO_4 = 2H_2O + SO_2 + HgSO_4$. Also by HNO_3: $3Hg + 8HNO_3 = 4H_2O + 2NO + 3Hg2NO_3$. Or: $3Hg_2 + 8HNO_3 = 4H_2O + 2NO + 3Hg_2 2NO_3$. **Oxides:** two, both basic. Hg_2O and HgO.

1. MERCUROUS OXIDE $\mathbf{Hg_2O}$, black. Unstable. From $\mathbf{Hg_2Cl_2} + 2KHO = 2KCl + H_2O + \mathbf{Hg_2O}$. 2. MERCURIC OXIDE $\mathbf{HgO}$, or RED OXIDE. A yellow powder, or in red scales, slightly soluble. By heating Hg at 400°C. for a long time, or by decomposing $Hg2NO_3$ by heat; or, from $\mathbf{HgCl_2}$ by $2KHO = 2KCl + H_2O + \mathbf{HgO}$. MERCURAMINE HYDRATE $\mathbf{Hg_4H_4N_2O_2,3H_2O}$, by pouring NH_3 upon precipitated HgO. Most powerful base. At 130° into: $3H_2O + Hg_4H_4N_2O_3$. **Sulphides.** 1. MERCUROUS SULPHIDE $\mathbf{Hg_2S}$, black and unstable. By heat into HgS + Hg. 2. **Mercuric sulphide** $\mathbf{HgS}$ = 3 vols. Native as "Cinnabar," in hexahedral prisms. The ore of Hg. Vermilion is artificial HgS. It is precipitated black by H_2S from mercuric salts. **Metallurgy.** *a.* By roasting and collecting the metal. $\mathbf{HgS} + O_2 = SO_2 + \mathbf{Hg}$. *b.* $\mathbf{HgS} + Fe = FeS + \mathbf{Hg}$. *c.* $4\mathbf{HgS} + 4CaO = CaSO_4 + 3CaS + 4\mathbf{Hg}$. **Salts.** 1. **Soluble mercurous.** NITRATE $\mathbf{Hg_2,2NO_3,2H_2O}$, in efflorescent prisms. Also: $Hg_2O,H_2O,3Hg_2,2NO_3$; and $2(Hg_2O,H_2O)3Hg_2,2NO_3$. ACETATE $\mathbf{HgC_2H_3O_2}$, in silvery scales, soluble in boiling water. 2. **Insoluble.** MERCUROUS CHLORIDE $\mathbf{Hg_2Cl_2}$, or "calomel" in 4-sided prisms, or as a whitish powder. By NH_3 into $\mathbf{NHg_2H_2Cl}$. $Hg_2Cl_2 + 2NH_3 = NH_4Cl + \mathbf{NHg_2H_2Cl}$. By lime-water into *black wash* (Hg_2O). *Prep.* $\mathbf{Hg_2}SO_4 + 2NaCl = Na_2SO_4 + \mathbf{Hg_2Cl_2}$. BROMIDE $\mathbf{Hg_2Br_2}$. IODIDE $\mathbf{Hg_2I_2}$, green; by light into HgI_2 + Hg. FERRICYANIDE $3\mathbf{Hg_2Fdcy_2}$, brownish-red. CHROMATE $3\mathbf{Hg_2CrO_4,Hg_2O}$, orange-red. 1. **Soluble mercuric salts.** MERCURIC CHLORIDE $\mathbf{HgCl_2}$, is corrosive sublimate. In needles, soluble in 16 of cold, and 3 of boiling water. Fuses at 265°C., and boils at 295°C. Violent acrid poison: antidote, white of eggs. Coagulates albumen, hence its use in kyanizing timber. Forms double salts with KCl, NaCl, and NH_4Cl. *Prep.* $\mathbf{HgSO_4} + 2NaCl = Na_2SO_4 + \mathbf{HgCl_2}$. BROMIDE $\mathbf{HgBr_2}$, crystallizable. MERCURIC CYANIDE $\mathbf{HgCy_2}$, rectangular prisms, soluble in 8 parts of water. By heat into Hg, Cy_2, and PARACYANOGEN. OXY-CYANIDE $\mathbf{HgO,HgCy_2}$, in needles. $K_4FeCy_6 + 3\mathbf{HgSO_4} = 2K_2SO_4 + FeSO_4 + 3\mathbf{HgCy_2}$. NITRATE $\mathbf{2Hg2NO_3,H_2O}$. Also: $HgO,Hg2NO_3,2H_2O$. 2. **Insoluble.** MERCURIC OXYCHLORIDES, by the action of $KHCO_3$ upon $HgCl_2$, or by boiling HgO with $HgCl_2$. $\mathbf{2HgO,HgCl_2}$. $\mathbf{3HgO,HgCl_2}$. $\mathbf{4HgO,HgCl_2}$. CHLOROSULPHIDE $\mathbf{2HgS,HgCl_2}$. White; obtained by adding H_2S to $HgCl_2$ in excess. CHLORO-AMIDE $\mathbf{NH_2HgCl}$, or "white precipitate" is made by adding NH_3 to $HgCl_2$. $HgCl_2 + 2NH_3 = NH_4Cl + \mathbf{NH_2HgCl}$. MERCURIC IODIDE $\mathbf{HgI_2}$, is scarlet and readily soluble in excess of potassium iodide. HYDRARGAMMONIUM IODIDE $\mathbf{NHg_2I,H_2O}$, is brown. It is occasioned by the use of Nessler's test (a solution of mercuric iodide in potassium iodide, to which potassium hydrate has been added) to a liquid containing NH_3. MERCURIC FERROCYANIDE $\mathbf{Hg_2FeCy_6}$, white. SULPHATE $\mathbf{HgSO_4}$, white crystalline powder, decomposed by water into $2HgO,HgSO_4$

or "mineral turpeth," which is yellow, and an acid salt which dissolves. DI-MERCURIC NITRATE **$2HgO,Hg2NO_3,H_2O$** is yellow.

Salts of mercury are readily reduced by Cu, and by stannous chloride. The **metal** is best weighed as such.

XXX. Cuprum or copper Cu = 63.5.

30. CUPRUM **Cu = 63.5.** This metal is frequently found native in cubes, octohedra, dendritic crystals, and massive. The name from Cyprus. Lustrous, malleable, ductile, tenacious, it is of a red colour. Sp. gr. 8.952. Melts at 1091°C. It is next to Ag as a conductor of heat and electricity. Corrodes slowly in damp air; rapidly in salt water. Heated to redness, black CUPRIC OXIDE **CuO** formed externally. H_2SO_4, boiled with Cu: **$Cu + 2H_2SO_4 = 2H_2O + SO_2 + CuSO_4$**. Nitric acid gives $Cu2NO_3$. **$3Cu + 8HNO_3 = 4H_2O + 2NO + 3(Cu2NO_3)$**. **Alloys.** BRASS is **Cu_2Zn**. MUNTZ METAL **Cu_2Zn_2**. SPECULUM METAL **Cu_4Sn**. BELL-METAL **Cu_3Sn**. Bronze contains less tin. **Oxides: Two basic oxides** and **one sub-oxide.** Cu_2O and CuO. Cu_4O. 1. SUBOXIDE **Cu_4O,xH_2O**; green hydrate. 2. **Cupreous oxide Cu_2O**, red; native in "ruby copper ore," in octohedra. As yellow hydrate $4Cu_2O,H_2O$. *Prep.* By reducing a cupric salt, or from a cupreous salt by KHO. It is soluble in NH_3, and forms a colourless liquid. 3. **Cupric oxide CuO.** Black. Rarely native. HYDRATE **CuH_2O_2**, blue, and soluble in NH_3, as an ammoniated salt of blue colour, $CuSO_4$, $4NH_3,H_2O$. Loses its water when boiled, and blackens. Gives a green colour to glass. CuO is best obtained by heating nitrate to redness. A cupric salt is reduced in presence of sugar; on addition of KHO and heat, cupreous oxide is thrown down. TRI-CUPRIC NITRIDE **Cu_3N**, dark-green powder. CUPREOUS HYDRIDE **Cu_2H_2** or CuH. At 70°C. into $H_2 + 2Cu$. PHOSPHIDE **Cu_2P_2**, black. **Sulphides. Cupreous sulphide Cu_2S.** A mineral, in 6-sided prisms. The "fine metal" of smelters. **Cupric sulphide CuS**, in flexible blue plates,—a rare mineral. As a dark-brown HYDRATE, from cupric salts by H_2S. **Copper-pyrites $FeCuS_2$**, both massive, and in tetrahedra of brassy lustre. The **ore** of copper. **Metallurgy.** 1. *Calcining.* Fe chiefly oxydized, S volatilizing as SO_2. 2. *Melting for coarse metal.* FeO slagged off by SiO_2 as Fe_2SiO_4: *Matt* Cu_2S with some Fe_2S_3 remaining. 3. *Recalcining.* All Fe oxydized. 4. *Melting for fine metal.* Remaining FeO slagged off; Cu_2S or "fine metal" remaining. 5. *Roasting and reduction.* 1. **$Cu_2S + 2O_2 = SO_2 + 2CuO$.** 2. **$2CuO + Cu_2S = SO_2 = 4Cu$.** *Blistered copper.* 6. *Refining.* Fused in a reverberatory furnace; much CuO formed, reduced by charcoal and *poling* with trunk of a young tree. **Cupreous salts.** Unimportant. **Cupric salts. Soluble.** CHLORIDE **$CuCl_2,2H_2O$**, green deliquescent needles. Copper foil burns in Cl_2. Soluble

in alcohol. BROMIDE $CuBr_2$. SULPHATE $CuSO_4,5H_2O$ in blue doubly-oblique rhombs, soluble in 4 of water. Anhydrous at 200°C. NITRATE $Cu2NO_3,6H_2O$, in blue rhomboidal prisms. ACETATE $Cu2C_2H_3O_2,H_2O$, in green oblique rhombic prisms. "Verditer." When verdigris is treated with water $CuO,2(Cu2C_2H_3O_2)$, $6H_2O$ dissolves. **Insoluble salts.** CARBONATES. $CuCO_3$ unknown. **Chessylite** $CuH_2O_2,2CuCO_3$, crystallizes in blue oblique-rhombic prisms. **Malachite** $CuH_2O_2,CuCO_3$, often beautifully veined. Common malachite is used as an ore. First roasted. CuH_2O_2, $CuCO_3 = H_2O + CO_2 + 2CuO$. Then $CuO + C = CO + Cu$. FERROCYANIDE Cu_2FeCy_6, red-brown. FERRICYANIDE Cu_2Fe6y, yellowish-green. CUPRIC ARSENITE $CuHAsO_3$, is Scheele's green. CUPRIC ARSENATE $CuHAsO_4$. is pale greenish blue. *Verdigris* is DI-CUPRIC ACETATE $CuO,Cu2C_2H_3O_2,6H_2O$, by water into: $4CuO$, $2\ Cu2C_2H_3O_2),3H_2O$ and a soluble sesqui-basic salt.

Copper is estimated as CuO, 100 parts of which contain 79.85 per cent. of metal.

XXXI. Indium In = 72?

31. INDIUM **In = 72**. White, malleable metal of sp. gr. 7.36. It is precipitated from its salts by Zn. Discovered by Reich and Richter in a zinc-blende at Freyberg. Exhibits in the spectroscope 2 bright lines in the blue and indigo, one line more refrangible than the blue line of Strontium. Its OXIDE is white and insoluble in alkalies. Not precipitated in acid solutions by H_2S. SULPHIDE is yellow. CHLORIDE white and deliquescent.

7. Gold, Platinum, Palladium, Rhodium, Ruthenium, Osmium, and Iridium.

XXXII. Aurum Au = 196.7.

32. AURUM or GOLD **Au = 196.7**. Always found native, both massive and crystallized in cubes. octohedra, and tetrahedra. In California, Australia, Ural Mountains, &c. Bright yellow, lustrous metal of sp. gr. 19.34. Most malleable; gold leaf $\frac{1}{300000}$ of an inch in thickness. Inferior to Ag and Cu in conductivity. Melts at 1102.2C°. Untarnishable. A noble metal. Only attacked by aqua regia; dissolved as AURIC CHLORIDE $AuCl_3$. And by Cl_2,Br_2 and F_2. **Alloys.** Standard gold contains 8.33 per cent. of Cu Ag, and Au, separated by quartation process; *i.e.*, fusing with so much Ag that the Au forms $\frac{1}{4}$. Au is left behind, when HNO_3 employed as a solvent. **Two oxides.** Au_2O and Au_2O_3. Both **basic**, but AURIC OXIDE Au_2O_3, as much electro-negative. 1. AUROUS OXIDE Au_2O, dark-green powder. Most unstable. AUROUS CHLORIDE $AuCl$, as a yellow powder, insoluble in water, is obtained by carefully heating $AuCl_3$ at 175°C. By boiling water, into 2Au and $AuCl_3$. 2. AURIC

OXIDE Au_2O_3, as a yellow hydrate from $AuCl_3$ by MgH_2O_2. At 245°C., into Au and O_2. Precipitated by KHO from $AuCl_3$. POTASSIUM AURATE $KAuO_2,3H_2O$. With NH_3 a fulminating compound. AUROUS-AURIC SULPHIDE Au_2S,Au_2S_3, is black, and soluble in alkaline sulphides. AURIC CHLORIDE $AuCl_3$ red, deliquescent salt. At 175°C. into AuCl, and then into Au and Cl. Solution reduced by: $2AuCl_3 + 6FeSO_4 = Fe_2Cl_6 + 2\ Fe_2 3SO_4) + 2Au$. $2AuCl_3 + 3H_2C_2O_4 = 6HCl + 6CO_2 + 2Au$. $2AuCl_3 + 6H_2O + 3SO_2 = 6HCl + 3H_2SO_4 + 2Au$. $2AuCl_3 + 3SbCl_3 = 3SbCl_5 + 2Au$. Also reduced by P_4, Cu, Hg, Zn, Fe. **Purple of Cassius** $SnAu_2Sn_2Au_6,4H_2O$. Used as a test and for colouring Bohemian glass.

Gold is always weighed as **Au**.

XXXIII. Platinum Pt = 197.

33. PLATINUM **Pt = 197**. Is always found native, and as an alloy with Palladium, Osmium, Iridium, Rhodium, and Ruthenium, in the Ural Mountains, Brazil, and Ceylon. Discovered by Wood in 1741. White, lustrous metal, very malleable and ductile. Sp. gr. 21.5. A noble metal. Aqua regia dissolves it as PLATINIC CHLORIDE $PtCl_4$. Very difficult of fusion. Can be welded. Spongy platinum is obtained by heating $2NH_4Cl, PtCl_4$. Platinum black is obtained by boiling a solution of platinous chloride in potassium hydrate with alcohol. **Metallurgy**. The platinum-ore is treated with aqua regia, which dissolves Pt and Pd as chlorides: the solution is precipitated by NH_4Cl as $2NH_4Cl,PtCl_4$, which by heat is changed into: $2NH_4Cl + 2Cl_2 + Pt$. **Two oxides**: feeble bases. 1. PLATINOUS OXIDE **PtO**, as black hydrate, by neutralizing a solution of $PtCl_2$ in KHO with H_2SO_4. PLATINOUS CHLORIDE $PtCl_2$ is olive-brown and insoluble in water. 2. PLATINIC OXIDE PtO_2 dark-brown. HYDRATE $PtO_2,2H_2O$: forms crystalline compounds with the alkalies. PLATINIC CHLORIDE $PtCl_4$ red, deliquescent salt, very soluble in alcohol and ether. When heated at 235°C., into $PtCl_2$; at a higher temperature into Pt and Cl_2. Forms double salts with all the alkaline chlorides. $2KCl,PtCl_4$, yellow and so nearly insoluble, especially in mixed alcohol-ether, that it is employed for estimating K_2 in combinations. $2NH_4Cl,PtCl_4$, also yellow and insoluble; see also Cs, Rb, and Na. PLATINOUS SULPHIDE PtS, is black. PLATINIC SULPHIDE PtS_2, also black, somewhat soluble in alkaline sulphides. [PLATINO-AMMONIA BASES. *Gros's salts*. DI-PLATINAMINE PERHYDROCHLORATE $PtN_4H_8,4HCl$. *Raewsky's salts*. NITRATE $Pt_2Cl_2N_8H_{20}O,4HNO_3$. *Reiset's*. PLATOSAMINE HYDROCHLORATE $PtN_2H_4,2HCl$. DIPLATOSAMINE HYDROCHLORATE $PtN_4H_{10},2HCl,H_2O$; *Magnus's* green salt contains

$PtCl_2$ in addition. *Gerhardt's.* PLATINAMINE HYDROCHLORATE $PtN_2H_2,4HCl$. DI-PLATINAMINE HYDROCHLORATE PtN_4H_8, $2HCl$.]

Platinum may be weighed either as **Pt**, or as $2NH_4Cl,PtCl_4$, which contains 44.17 per cent. of **Pt**.

[XXXIV. Palladium Pd = 106.5.

34. PALLADIUM **Pd = 106.5.** Discovered by Wollaston in 1803. Very white, hard metal; malleable, ductile, and tenacious. Sp. gr. 11.4 to 11.8. Not fusible in a wind-furnace. Dissolved by HNO_3, and by aqua regia. Tincture of I heated on Pd leaves a blue stain. METALLURGY. After removal of $2NH_4Cl$, $PtCl_4$. Mercuric cyanide is added: PALLADIC CYANIDE $PdCy_2$ is precipitated. Ignited, it leaves **Pd**. Three oxides: all basic. PALLADIOUS OXIDE Pd_2O. PALLADIC OXIDE **PdO**, black. By heating $Pd2NO_3$ to redness. PALLADIC DI-OXIDE PdO_2, yellowish-brown hydrate. From $2KCl,PdCl_4$ by KHO. PALLADIC SULPHIDE **PdS**, from PdO salts by H_2S. PALLADIC CHLORIDE $PdCl_2$ black. Crystals brown, hydrated. AMMONIA-BASES like those of Pt. PALLADAMINE PdN_2H_6O. PALLADIC IODIDE PdI_2, black powder, insoluble. CYANIDE $PdCy_2$, yellow. SULPHATE $PdSO_4$; deliquescent red-brown salt.

Palladium precipitated as $PdCy_2$, weighed as **Pd**.]

[XXXV. Rhodium Ro = 104.3.

35. RHODIUM **Ro = 104.3.** Discovered by Wollaston in 1803. One-half per cent. of platinum ores. Obtained from $3NaCl$, $RoCl_3,9H_2O$, which is INSOLUBLE in ALCOHOL. **Ro** obtained by precipitation with Zn. White, malleable metal of sp. gr. 12.1. Salts rose-red; from ῥόδον, "a rose." **Two oxides:** one basic. RHODIUM SUB-OXIDE **RoO**. RHODIUM OXIDE Ro_2O_3, greenish-grey hydrate. **RoS**. Ro_2S_3, as a brown hydrate. $RoCl_2$; Ro_2Cl_3. RHODIUM CHLORIDE $RoCl_3$. From $3KCl,RoCl_3$ by H_2F,SiF_4.]

[XXXVI. Ruthenium Ru = 104.2.

36. RUTHENIUM **Ru = 104.2.** Discovered by Claus in Pt. ores in 1845. Hard, brittle metal. Most infusible. Sp. gr. 11.4. Becomes oxydized when heated, or by fusion with KNO_3. **Four oxides.** **RuO.** Ru_2O_3, the most stable. RuO_2 and RUTHENIC ANHYDRIDE RuO_3. SULPHIDES. **RuS**, Ru_2S_3, RuS_3. CHLORIDES. $RuCl_2$. $RuCl_3$. $RuCl_4$. **Metallurgy.** The platinum residues are roasted in a current of air: RuO_2 is mechanically carried forward by Osmium tetroxide, and deposited in square prisms.]

[**XXXVII. Osmium Os = 199.**

37. OSMIUM **Os = 199.** Discovered by Tennant in 1803. Chiefly in Osmium-iridium. Bluish-white metal of sp. gr. 21.4. Very infusible. Burns to OSMIUM TETROXIDE **OsO_4**. From $OsO_4 + 8Hg + 8HCl = 4H_2O + 4Hg_2Cl_2 + Os$. From the pungent irritating odour of OsO_4, it has its name from ὀσμή "smell." **Five oxides. OsO. Os_2O_3, OsO_2. OsO_3. OsO_4.** OSMIUM TETROXIDE **OsO_4**, in colourless needles, very fusible: liquid boils at 100°C. Odour very powerful. **OsS_4**, as a black hydrate by H_2S. CHLORIDES. **$OsCl_2$. $OsCl_3$. $OsCl_4$. $OsCl_6$.** POTASSIUM-OSMIUM CHLORIDE **$2KCl,OsCl_4$**, in red octohedra.]

[**XXXVIII. Iridium Ir = 197.1.**

38. IRIDIUM **Ir = 197.1.** Discovered by Tennant in 1803. Sometimes native. Also in Iridium-osmium. White, brittle metal, of sp. gr. 21.15. **Metallurgy.** After roasting the platinum residues, they are fused with KHO, and thus Ru is further removed by lixiviation: they are then fused with KNO_3, and the product boiled with water in order to remove **$K_2OsO_4,2H_2O$.** The residue consists of Ir_2O_3 and Ro_2O_3. Boiled with aqua regia, **Ir** is dissolved as **$IrCl_4$**, leaving Ro_2O_3. On adding 2KCl, POTASSIUM IRIDIC CHLORIDE **$2KCl,IrCl_4$** is deposited in crystals. In a stream of H_2, the salt is reduced, and KCl removed by washing. **Three oxides. IrO. Ir_2O_3. IrO_2.** SULPHIDES. **IrS. Ir_2S_3. IrS_2.** CHLORIDES. **$IrCl_2$. $IrCl_3$. $IrCl_4$.** From the rapid changes of colour, owing to the rapidity with which the oxides pass into one another, the name Iridium was given, from Iris, "the rainbow."]

8. Metals whose oxides are either weak bases, or play the part of acids. Includes Tin, Molybdenum, Wolfram, Niobium, Tantalum, and Vanadium.

XXXIX. Stannum or Tin Sn = 118.

39. STANNUM **Sn = 118.** Very white, lustrous, malleable metal. Sp. gr. 7.292. Melts at 227.8°C. Tarnishes slowly in air. By HCl, slowly into STANNOUS CHLORIDE $SnCl_2$. Boiled with H_2SO_4, into STANNIC SULPHATE $Sn2SO_4$. HNO_3 into META-STANNIC ACID $H_2Sn_5O_{11},4H_2O$. **Alloys.** *Britannia metal*, equal parts of Sn, brass, Sb and Bi. *Pewter*, 4 parts of Sn and 1 of Pb. *Fine Solder*, 2 parts of Sn to 1 of Pb. *Common solder* of equal parts of Sn and Lead. *Coarse solder*, 1 of Sn to 2 of Pb. See **Copper.** Amalgams. See **Hg. Three oxides.** 1. STANNOUS OXIDE **SnO.** Black, burning to SnO_2, when heated. HYDRATE **$2SnO,H_2O$**, white, soluble in KHO. **Stannic oxide SnO_2**, white. Native as tin-stone, in square prisms and massive.

The *ore* of Sn. In veins in the Granite and Killas in Cornwall, Malacca, &c. **Metallurgy.** By careful roasting, much As_2O_3 and SO_2 is got rid of, from the accompanying FeSAs and $FeCuS_2$: Fe_2O_3 and $CuSO_4$ remain mixed with the tin-ore. It is then moistened, exposed to air and lixiviated. The washed ore is then reduced with charcoal. $\mathbf{SnO_2} + 2C = 2CO + \mathbf{Sn}$. STANNIC ACID $\mathbf{H_2SnO_3}$, white gelatinous precipitate, forms salts: $K_2SnO_3,3H_2O$ and Na_2SnO_3, $3H_2O$. Insoluble in NH_3. In HCl, as stannic chloride $SnCl_4$. At 140°C. into metastannic acid. From $SnCl_4$ by NH_3, or by $CaCO_3$. METASTANNIC ACID $\mathbf{H_2Sn_3O_{11},4H_2O}$. By the action of HNO_3 upon Sn. Insoluble in HNO_3. HCl combines with it: insoluble. Soluble in KHO. METASTANNATES. $K_2Sn_3O_{11},4H_2O$. 3. STANNOUS STANNIC OXIDE $\mathbf{Sn_2O_3}$. SULPHIDES. STANNOUS SULPHIDE **SnS**, brown. By H_2S from $SnCl_2$. Soluble as SnS_2 in $(NH_4)_2S_2$. STANNIC SULPHIDE $\mathbf{SnS_2}$, as yellow hydrate, easily soluble in NH_4HS or any alkaline sulphide. "Mosaic gold" is SnS_2, bright-yellow flakes. CHLORIDES. STANNOUS CHLORIDE $\mathbf{SnCl_2,2H_2O}$. In prisms. By water, into OXY-CHLORIDE $\mathbf{SnO,SnCl_2,2H_2O}$ and 2HCl. Reduces: $2HgCl_2 + SnCl_2 = SnCl_4 + Hg_2Cl_2$. $Hg_2Cl_2 + SnCl_2 = SnCl_4 + 2Hg$. $SnCl_2$ may be obtained as *Butter of tin*, by distilling $HgCl_2 + Sn = Hg + SnCl_2$. STANNIC CHLORIDE $\mathbf{SnCl_4,5H_2O}$ in rhomboids. Obtained by adding aqua regia to stannous chloride. $SnCl_4$, by distilling $2HgCl_2 + Sn = 2Hg + SnCl_4$. *Purple of Cassius* $SnAu_2Sn_2O_6,4H_2O$.

Tin is estimated as $\mathbf{SnO_2}$, which contains 78.66 per cent. of **Sn**.

[XL. Molybdenum Mo = 96.

40. MOLYBDENUM **Mo = 96.** White, brittle metal, very difficult of fusion. Sp. gr. 8.62. Name given from μολύβδαινα "a mass of lead," which its ore, MOLYBDIC SULPHIDE $\mathbf{MoS_2}$, resembles. By roasting, into MOLYBDIC ANHYDRIDE $\mathbf{MoO_3}$; reduced by charcoal in a smith's forge in a crucible lined with charcoal. **Three oxides,** two basic and one acid. **MoO. $\mathbf{MoO_2}$. $\mathbf{MoO_3}$.** MOLYBDOUS OXIDE **MoO,** black. Hydrate, insoluble in alkalies. From MoO_3 by Zn and HCl. MOLYBDIC OXIDE $\mathbf{MoO_2}$, dark brown. Igniting Na_2MoO_3, and NH_4Cl, and digestion in KHO solution, to remove any molybdate. MOLYBDIC ANHYDRIDE $\mathbf{MoO_3}$. Buff colour. Reddens litmus. MOLYBDATES. $(NH_4)_2MoO_3$ in square prisms. **Lead Molybdate $\mathbf{PbMoO_4}$,** native in yellow crystals. MOLYBDIC TETRAMOLYBDATE $MoO_2,4MoO_3$, is blue. By $SnCl_2$ in a molybdate. SULPHIDES $\mathbf{MoS_2}$. $\mathbf{MoS_3}$. $\mathbf{MoS_4}$. **Molybdic sulphide $\mathbf{MoS_2}$** in thin flexible, plumbago-like leaves. The ore of Mo. By roasting and by HNO_3 into MoO_3. CHLORIDES. $\mathbf{MoCl_2}$. $\mathbf{MoCl_4}$. CHLORO-MOLYBDIC ACID $\mathbf{MoO_2Cl_2}$.

Mo is estimated as $\mathbf{MoS_2}$: contains **60** per cent. of metal.]

[XLI. Tungsten W = 184.

41. TUNGSTEN OF WOLFRAM **W = 184.** Iron-grey metal of sp. gr. 17.6. From TUNGSTIC ANHYDRIDE **WO_3** with charcoal in a smith's forge. By aqua regia and by HNO_3 into WO_3. **Two oxides**; and an intermediate one. **WO_2**, brown. By heating WO_3 in a stream of H_2. $Na_2O,WO_2 2WO_3$, in yellow cubes, with metallic lustre. TUNGSTIC ANHYDRIDE **WO_3**, straw-yellow powder. **Calcium tungstate $CaWO_4$**, is "Scheelite" and **$MnWO_4,3FeWO_4$**, "Wolfram." TUNGSTIC ACID **H_2WO_4**. META-TUNGSTIC ACID **$H_2W_4O_{13}$**. SULPHIDES. **$WS_2.WS_3$**. CHLORIDES. **$WCl_4.WCl_6$**. CHLORO-TUNGSTIC ACID **WO_2Cl_2**.

Tungsten is weighed as **WO_3**; contains 79.32 per cent. of **W**.]

[XLII. Columbium or Niobium Nb = 94.

42. NIOBIUM **Nb = 94.** Found by Hatchett in 1801 in Columbite. Known only as a black powder, not acted upon by HNO_3, and little by HCl or H_2SO_4. NIOBIC ANHYDRIDE **Nb_2O_5**. CHLORIDE **$NbCl_5$**. FLUORIDE **NbF_5**. OXY-FLUORIDE **$NbOF_3$**. In its affinities resembles Phosphorus.]

[XLIII. Tantalum Ta = 182.

43. TANTALUM **Ta = 182.** In tantalite and yttro-tantalite by Ekeberg. Ta_2O_5.? POTASSIUM TANTALIC FLUORIDE **$2KF,TaF_5$**.]

[XLIV. Vanadium V = 51.3.

44. VANADIUM **V = 51.3.** Discovered in 1830 by Sefström. Metal not known. **Four oxides.** **V_2O_2**. **V_2O_3**. **V_2O_4**. **V_2O_5**. Salts of **V_2O_2**, lavender coloured. **V_2O_3** is black. Obtained from V_2O_5 by reduction with H_2. Salts brown or green. **V_2O_4** forms blue salts. VANADIC ANHYDRIDE **V_2O_5**, brownish-red, fusible, sparingly soluble, but strongly acid. AMMONIUM META-VANADATE **NH_4VO_3**, in crystalline grains. "Vanadinite' is **$PbCl_2,3(Pb_3{}_2VO_4)$** is the chief ore of vanadium. VANADIUM CHLORIDES not well known. VANADIC OXY-CHLORIDE **$VOCl_3$**, yellow, fuming, volatile liquid. By $3H_2O = 3HCl + H_3VO_4$. NITRIDES. **VN. VN_2**.]

END OF INORGANIC CHEMISTRY.

SKELETON NOTES ON ANALYSIS.

Preliminary Tests.

1. **For bases; in soluble salts.** Including As_2O_3, As_2O_5, and Cr_2O_3.

PRELIMINARY EXAMINATION.—*a.* **Coloured** or **colourless.**—*b.* Neutral, alkaline, or acid, to **test papers**;—if *acid*, effervescence or not, with or without precipitate on addition of **sodium carbonate**;—if *alkaline*, from nature of the salt or from free alkali or alkaline earth, by **nitrate of silver.**—*c.* **Sodium carbonate** (unless previously added): apply heat, if no precipitate in the cold. If no precipitate even on heat, absence of all metals the carbonates of which are insoluble. *d.* **Heat on platinum**; or in *test-tube*, if a dilute solution. Completely volatile without residue: or with residue, volatile (salts of NH_3, Hg, As_2O_3, As_2O_5; chlorides of Sn, Sb, certain organic acids, &c.): or with residue, visibly decomposed, with or without carbonaceous residue (various *organic salts*, those of *alkalies* and *alkaline earths* leaving an ash alkaline to test-paper, and effervescing on addition of HCl; also certain *organic acids*): or with carbonaceous residue burning to CO_2 (certain organic acids). Giving **colour** to flame. (Potassium, violet; Sodium, yellow; Lithium, purple; Barium, yellowish-green; Strontium, crimson; Calcium, reddish-yellow; Free boracic and phosphoric acids, and salts of Thallium, green; Copper, green; Cupric chloride, blue; Salts of Antimony, Arsenic, and Lead, blue, &c.) **Fuse** on platinum (nearly all salts of alkalies and alkaline earth). Moisten residue with H_2SO_4, and heat again; if borates and phosphates, green colour to flame. *e.* **Deflagrate on charcoal**: nitrates, chlorates, bromates, and iodates.

N.B.—It is frequently advisable to examine the volatilized substance. Then transfer to narrow glass-tube open at both ends, if a solid; or heat in a narrow test-tube. If the substance solid, look to colour; form; try effects of heat, solubility in water. If portion insoluble in water, use **HCl**. If still a residue, **HNO_3**, must be tried. Any portion insoluble in both acids, must be fused with four times its weight of a mixture of Na_2CO_3 and K_2CO_3. OBSERVE THE FOLLOWING ORDER IN APPLYING THE TESTS TO SOLUTION OF A SALT CONTAINING ONE BASE: Test-papers; Sodium carbonate; Hydrochloric acid; Hydrochloric *and* Hydrosulphuric acid; Ammonium hydrosulphide; Ammonium carbonate with chloride; Sodium ammonium phosphate; Potassium hydrate; and, finally, Platinic chloride with hydrochloric acid. **For discovery of the acid** in a **salt** (removing the bases of the heavy

metals if necessary by sodium carbonate), the leading tests are: Hydrochloric acid, Hydrochloric and Hydrosulphuric acid, Barium chloride with subsequent addition of nitric acid, Silver nitrate, with subsequent addition of nitric acid, and ammonia to the carefully-washed precipitates. In case of nitrates, liberate the acid by oil of vitriol, and add the characteristic tests, metallic copper and Ferrous sulphate. Salts of organic acids recognized by effects of heat on platinum; by testing the residue, if any, with red litmus; and by addition of hydrochloric acid.

Tests for Bases: in soluble salts.

I. Hydrochloric acid occasions a precipitate. Sulphides black or brown-black, insoluble in NH_4HS. [N.B.—**HCl** added carefully will also precipitate Antimonous hydrate from tartar emetic, Arsenious acid from an arsenite, and Potassium hydrogen tartrate from potassium tartrate: *precipitates readily soluble in excess.* If weak solution of lead-salt HCl may not occasion a precipitate, or one immediately soluble: then add **H_2S.**]

1. **Lead oxide PbO**, yellow. PbH_2O_2, white. Chief common salts. Acetate, nitrate and chloride. Neutral or feebly acid. Goulard's extract alkaline.) **HCl**, as white $PbCl_2$, soluble in HCl and in boiling water, *not* in NH_3. In fresh portion, **H_2S** black PbS. In solutions of $PbCl_2$ in HCl, a *red* precipitate of $2PbCl_2$, $3PbS$. **Na_2CO_3**, white PbH_2O_2, $2PbCO_3$. **KHO**, white PbH_2O_2 soluble in large excess. **NH_3**, white PbH_2O_2, partially; increased by heat. **H_2SO_4**, white $PbSO_4$. **$K_2Cr_2O_7$** yellow $PbCrO_4$, soluble in KHO. **KI**, yellow PbI_2, soluble in much boiling water. **K_4FeCy_6**, white Pb_2FeCy_6. The metal precipitated by Zinc. On **charcoal** with blowpipe, yellow crust; malleable globules. N.B.—Lead must also be sought for in Group II. by H_2S.

[2. **Thallium oxide Tl_2O**, in hydrated prisms, very soluble in H_2O, and alkaline. (Chief salts, nitrate, sulphate, and chloride.) **HCl**, yellowish-white TlCl, sparingly soluble, less in HCl. **H_2S**, little reaction. **NH_4HS**, brown-black Tl_2S. **KHO** and **NH_3**, no precipitate. **Na_2CO_3**, white Tl_2CO_3 only in strong solutions. **H_2SO_4**, none. **$K_2Cr_2O_7$**, pale-yellow Tl_2CrO_4. **KI**, reddish-yellow TlI. **Zn** precipitates **Tl**. On charcoal with **Na_2CO_3**, brown crust, with malleable metal, like lead. Heated in glass tube, a brown sublimate.]

3. **Mercurous oxide Hg_2O**, black. (Chief salt, nitrate, strongly acid. Insoluble salt, Mercurous chloride Hg_2Cl_2.) **HCl**, yellowish-white Hg_2Cl_2, insoluble in H_2O, blackens with NH_3, into NHg_2H_2Cl. **H_2S**, black Hg_2S. **Na_2CO_3**, black Hg_2O. **KHO**, black Hg_2O. **KI**, green Hg_2I_2. **$K_2Cr_2O_7$**, red $Hg_2O,3Hg_2CrO_4$. **K_4FeCy_6**, white Hg_2FeCy_6. **$SnCl_2$**, first, white Hg_2Cl_2, then grey Hg. Precipitated as **Hg** by Cu, Zn, Fe: **Hg**, sublimes in tube.

Salts volatile on **Pt** foil, with or without decomposition. Reduced by **Na_2CO_3**, in a tube.

4. **Argentum oxide Ag_2O**, dark brown, soluble in NH_3. (Chief soluble salt **$AgNO_3$**, neutral.) **HCl**, white AgCl, insoluble in H_2O, and in HNO_3; *soluble* in NH_3. **H_2S**, black Ag_2S. **Na_2CO_3**, white Ag_2CO_3, soluble in NH_3, and Ammonium salts. **KHO**, brown Ag_2O. Also NaHO, BaH_2O_2, SrH_2O_2, and CaH_2O_2. **NH_3** brown Ag_2O, in neutral sols. only. **KI**, yellowish AgI insoluble in NH_3. **$K_2Cr_2O_7$**, crimson Ag_2CrO_4. Precipitated by **Fe, Cu, Zn, Hg**. On charcoal with **Na_2CO_3**, reduced without incrustation; silver-white.

II. HCl + H_2S. Metals precipitated as sulphides, in HCl solution by H_2S.

A. Soluble in NH_4HS or better in $(NH_4)_2S_2$.

Arsenicum as **arsenious anhydride**, **As_2O_3**, or as a soluble arsenite. (Chief soluble salt K_3AsO_3, strongly alkaline.) **HCl** no reaction, except in concentrated solutions: then white As_2O_3, soluble in excess. **HCl + H_2S**, yellow As_2S_3, soluble in NH_3, in KHO, in NH_4HCO_3, and in NH_4HS. **$BaCl_2$**, white $BaHAsO_3$, soluble in HNO_3. **$AgNO_3$**, yellow Ag_3AsO_3, soluble in NH_3 and in HNO_3. In sols. of As_2O_3, NH_3 must be carefully added after addition of $AgNO_3$. **$CuSO_4$**, green $CuHAsO_3$, soluble in HNO_3, and in NH_3. In sols. of As_2O_3, NH_3 must be added carefully after $CuSO_4$ has been used. **Reinsch's test**: **Cu** in **HCl** solution; Cu withdrawn, washed, dried at 100°C., and placed in narrow quill-tube and heated; As_2O_3 in octohedra, sublime. **Marsh's test**: AsH_3 burns to H_2O, and As_2O_3 with bluish-white flame. If incompletely burnt, **As** is deposited, *soluble* in **$CaOCl_2$**. On **Pt**, As_2O_3 with bluish flame. On charcoal, garlic odour. Heat in tube with black flux, **As** volatilizes.

Arsenicum as **arsenic acid**, **H_3AsO_4**; **anhydride As_2O_5**, and soluble **arsenate**. (Chief salt, $Na_2HAsO_4,12H_2O$.) **HCl** no visible reaction. **HCl + H_2S**, after a time on heating, or immediately, yellow $S_2 + As_2S_3$, soluble in KHO, NH_3, NH_4HS and NH_4HCO_3. **$BaCl_2$**, white $BaHAsO_4$, soluble in HNO_3. **$AgNO_3$**, liver-brown Ag_3AsO_4, soluble in NH_3: not precipitated in acid sols. **$CuSO_4$**, blue $CuHAsO_4$. For other tests see: **Arsenious anhydride**.

5. **Stannic oxide SnO_2** white: in stannic salts. (Chief salt $SnCl_4$. Colourless, strongly acid. Decomposed by much water.) **HCl** no reaction. **HCl + H_2S**, dirty-yellow SnS_2,H_2O soluble in NH_4HS, and in KHO. **Na_2CO_3**, white H_2SnO_3, with effervescence. **KHO**, white H_2SnO_3, soluble in excess. **NH_3**, white H_2SnO_3. On charcoal, with **Na_2CO_3**, metallic tin, malleable, without incrustation.

6. **Stannous oxide SnO**, black. **SnH_2O_2**, white, soluble in excess of KHO. (Chief salt $SnCl_2$. Decomposed by H_2O into white $SnO,SnCl_2.2H_2O$.) **HCl**, no reaction, except clearing a turbid solution. **HCl + H_2S**, brown SnS,H_2O, soluble in $(NH_4)_2S_2$, or in NH_4HS + flowers of sulphur; re-precipitated yellow, as $SnS_2.H_2O$ by HCl. **Na_2CO_3**, white SnH_2O_2, with effervescence. **KHO**, white SnH_2O_2, soluble in excess. **NH_3**, white SnH_2O_2. **$HgCl_2$**, first white Hg_2Cl_2, then grey Hg. **$AuCl_3$** to mixed stannous-stannic salt, Purple of Cassius $SnAu_2Sn_2O_6,4H_2O$. On **charcoal** with Na_2CO_3, metallic Sn without crust.

7. **Antimonous oxide Sb_2O_3**. Chief salts: Tartar emetic $2[KSbC_4H_4O_7],H_2O$ and antimonous chloride $SbCl_3$. Solutions of tartar emetic nearly neutral, precipitated white by HCl, easily soluble in excess. Solutions of $SbCl_3$, strongly acid, decomposed by water into white SbOCl, soluble in $H_2C_4H_4O_6$. By **H_2S** as orange-red Sb_2S_3, soluble in NH_4HS, in KHO, and, with decomposition, in HCl. Not in NH_3 nor in $(NH_4)_2CO_3$. **Na_2CO_3**, white hydrate, with effervescence. **KHO**, white hydrate, soluble in excess. **NH_3**, white hydrate; in tartar emetic by heat. By **Cu** in HCl solution, grey deposit. Marsh's test. On **charcoal**, with **Na_2CO_3**, brittle, metallic globules, with bluish-white incrustation.

[8. **Auric oxide Au_2O_3**. Chief salt, auric chloride $AuCl_3$, strongly acid, yellow or red. By **H_2S**, as black Au_2S,Au_2S_3, soluble in much $(NH_4)_2S$. **KHO**, yellowish-brown aurate. **NH_3**, yellow, fulminating. **K_4Cfy**, emerald-green colour. **$FeSO_4$**, metallic Au as a brown powder. Metallic **tin** or Stannous stannic chloride, purple of Cassius $SnAu_2Sn_2O_6,4H_2O$. **Zn** precipitates Au. Reduced by heat alone.

[9. **Platinic oxide PtO_2**. Chief salt: Platinic chloride $PtCl_4$, strongly acid, yellow or red. By **H_2S**, as $PtS_2.H_2O$, brownish-black, soluble in large excess of $(NH_4)_2S$. **KHO** in acid solution. yellow $2KCl,PtCl_4$. **NH_3**, yellow $2NH_4Cl,PtCl_4$. **$SnCl_2$**, red-brown colour. **KI**, deep claret colour and brown precipitate. On charcoal or Pb, reduced. No crust.]

II. *continued:* **Metals precipitated as sulphides in HCl solution by H_2S. (CrO_3 becomes Cr_2O_3, and Fe_2Cl_6 becomes $FeCl_2$.**
See **Chromic acid** H_2CrO_4 and **Ferric salts.**)

B. Insoluble in $(NH_4)_2S$ or in $(NH_4)_2S_2$.

Includes salts of Pb, Bi, Hg, Cu, Cd, Fe_2O_3. N.B.—H_2S is decomposed, with separation of sulphur, by free HNO_3, permanganates, H_2SO_3, Cl_2, Br_2, and I_2. **Lead salts** and **Thallium salts** described at p. 63.

10. **Bismuth oxide Bi_2O_3**, yellow; **Hydrate** $BiHO_2$, white.

Chief salts: Bismuth nitrate $Bi_3NO_3,5H_2O$ and chloride $BiCl_3$. Solutions colourless, strongly acid. Decomposed by water respectively into sub-nitrate $Bi_2O_3,2HNO_3$ and oxy-chloride $2(Bi_2O_3BiCl_3),H_2O$. Precipitate increased by $H_2C_4H_4O_6$. **H_2S**, black Bi_2S_3,H_2O. **Na_2CO_3**, white hydrate. **KHO**, white hydrate. **NH_3**, white hydrate. **$K_2Cr_2O_7$**, yellow chromate. **K_4Cfy**, white. **K_3Cdfy**, pale yellow. **KI**, brown, soluble. **Zn**, **Cu**, and **Sn** precipitate Bi. Reduced on **charcoal** with **Na_2CO_3**, reddish, brittle bead, with yellowish crust.

11. **Mercuric oxide HgO**, yellow or red. Chief salts: MERCURIC CHLORIDE $HgCl_2$ and NITRATE $2(Hg2NO_3),H_2O$. The former faintly, the latter strongly acid. **$HCl + H_2S$**, black HgS. N.B.—In *solutions* of **$HgCl_2$**, first a white chloro-sulphide $2HgS,HgCl_2$, then yellow, orange, red-brown, and black HgS. **KHO**, yellow HgO. NH_3 do. *But*, in solutions of $HgCl_2$, white precipitate HgH_2NCl. **Na_2CO_3**, yellow HgO. **$NaHCO_3$** red OXY-CHLORIDE $2HgO,HgCl_2$. **KI** scarlet HgI_2, soluble. **$SnCl_2$**, reduces $HgCl_2$ first to Hg_2Cl_2 and then to Hg_2. **K_4Cfy**, white, becoming blue. **K_3Cdfy**, yellow: none in $HgCl_2$. **Cu** and **Zn** reduce to Hg. Salts volatile, with or without decomposition. Nitrate first reduced to red HgO, and then into $Hg+O_2$. Heated with black flux in tube, Hg sublimes.

12. **Cupric oxide CuO**, black. **Hydrate** CuH_2O_2, light blue. Chief salts: Cupric sulphate $CuSO_4,5H_2O$; chloride $CuCl_2,2H_2O$ and nitrate $Cu2NO_3,6H_2O$. Salts green or blue, slightly acid reaction. **HCl**, blue to green, in sulphate. **$HCl + H_2S$**, black CuS,H_2O, with brown tinge to solution. **KHO**, pale blue CuH_2O_2, into H_2O and black CuO, on boiling. **NH_3**, blue precipitate, soluble, with deep-blue colour. **Na_2CO_3**, pale blue CuH_2O_2, $CuCO_3,H_2O$. **K_4Cfy**, red-brown Cu_2Cfy. **K_3Cdfy**, yellowish-green. **Fe** reduces. Green colour to flame, chloride blue. With borax, green bead in outer flame, red in inner. On charcoal, red, malleable metal. No crust.

13. **Cadmium oxide CdO**; brown. **Hydrate** CdH_2O_2, white. Chief salts: Sulphate $CdSO_4$ and chloride $CdCl_2,2H_2O$. Faintly acid. **$HCl + H_2S$**, yellow CdS. **KHO**, white CdH_2O_2. **NH_3**, white CdH_2O_2, readily soluble. No precipitate in acid solutions. **Na_2CO_3**, white $CdH_2O_2,CdCO_3$. **K_4Cfy**, yellowish-white Cd_2Cfy. **K_3Cdfy**, yellow. **Zn**, metallic Cd. On **charcoal** with **Na_2CO_3**, reduced to white, malleable Cd, with ring of brown CdO.

[14. **Palladium oxide PdO**, black. **Hydrate** PdH_2O_2, dark brown. Chief salt: Palladium chloride $PdCl_2$, brown or red solution. **$HCl + H_2S$**, black PdS. **KHO**, red basic salt, soluble by heat in excess. **NH_3**, flesh-coloured precipitate, soluble. **Na_2CO_3**, brown PdH_2O_2. **KI**, black PdI_2. **$HgCy_2$** yellowish $PdCy_2$. **$FeSO_4$** reduces salts of Pd.]

15. **Ferric oxide** Fe_2O_3, red-brown; **hydrate** $2Fe_2O_3,3H_2O$ red-brown. Chief salts: Ferric chloride $Fe_2Cl_6,6H_2O$, sulphate $Fe_23SO_4,9H_2O$. Yellow or red-brown. Acid reaction. HCl, slight change of colour. **HCl + H_2S** reduces to ferrous salt, with pale-yellow precipitate of S. Thus: $2Fe_2Cl_6 + 2HCl + 2H_2S = 6HCl + S_2 + 4FeCl_2$.

Chromic acid H_2CrO_4, crimson. Chief salts: POTASSIUM DICHROMATE $K_2Cr_2O_7$, red, and chromate K_2CrO_4, yellow. **HCl** deepens the red and reddens the yellow. **HCl + H_2S**, to green Cr_2Cl_6 with deposit of S. $2K_2Cr_2O_7 + 16HCl + 6H_2S = 3S_2 + 14H_2O + 4KCl + 2Cr_2Cl_6$. **Alcohol** reduces to green or violet chromic salts. **$BaCl_2$**, yellow $BaCrO_4$, soluble in HNO_3. **$Pb2C_2H_3O_2$**, yellow $PbCrO_4$, soluble in KHO. **$AgNO_3$**, crimson Ag_2CrO_4. **Hg_22NO_3**, brick-red $Hg_2O,3Hg_2CrO_4$. Salts brown by heat. With microcosmic salt, green.

III. Metals not precipitated in acid solutions by H_2S, but in neutral solutions by NH_4HS or by $(NH_4)_2S$.

[If HCl occasions precipitate, boil and filter. To the filtrate add H_2S, boil, filter off the sulphides, neutralize with NH_3, and add NH_4HS. Salts of **Fe**, **Co**, **Ni**, **Mn**, **Zn**, **Al**, and **Cr** precipitated. FeS, CoS, and NiS black. MnS,H_2O, flesh-coloured. ZnS,H_2O, white. $Al_2H_6O_6$, white, soluble in KHO. $Cr_2H_6O_6$, $4H_2O$, greenish, soluble in KHO, with green colour.]

15. **bis. Ferric oxide** Fe_2O_3, red or red-brown. **Hydrate** $2Fe_2O_3,3H_2O$ red-brown. Salts yellow or red-brown. Acid reaction. **HCl + H_2S**, reduction to ferrous salt, with deposit of S, and loss of colour. **Na_2CO_3**, with effervescence, reddish-yellow hydrate. **NH_4HS** black, hydrated sulphide. **KHO**, red-brown hydrate. **NH_3**, do. **K_4FeCy_6**, Prussian blue $Fe_4Fe_3Cy_{18}$. **K_3FeCy_6** change of colour. **KCNS**, blood-red colour Fe_23CNS. On **platinum**, red-brown residue. On **charcoal** with **Na_2CO_3**, reduction to Fe without fusion or crust.

16. **Ferrous oxide FeO** black; hydrate FeH_2O_2, white; most unstable. Chief salt: Green vitriol $FeSO_4,7H_2O$; slightly acid. **HCl** to yellow colour. **HCl + H_2S** no precipitate. **NH_4HS** black FeS,H_2O, insoluble. **Na_2CO_3**, dirty white $FeCO_3$. **KHO** whitish hydrate, to dirty green, and finally red-brown. **NH_3** whitish hydrate, immediately to dirty green: somewhat soluble in excess and by exposure to brown-red hydrated peroxide. **K_3FeCy_6**, Turnbull's blue $Fe_3Fe_2Cy_{12}$. **K_4FeCy_6**, greenish-white precipitate of Everitt's salt $KFeCy_3$. Blue if any Ferric salt. Heated on **C** with **Na_2CO_3**, reduced without fusion: no crust. With **borax**, in inner flame, green; in outer red, fading on cooling.

17. **Cobalt oxide. CoO**, grey: **CoH_2O_2** dirty red. Chief salt:

Chloride, red, slightly acid. **HCl** no reaction, or red to blue. **HCl + H_2S** no reaction. **NH_4HS**, black CoS,H_2O, insoluble. **Na_2CO_3**, red $4CoO,2CO_2.7H_2O$ **$(NH_4)_2CO_3$** red, soluble. **KHO** blue, basic; dirty red hydrate by boiling. **NH_3** blue, basic; soluble with brownish colour in excess; becomes red. **KCy**, pale brown $CoCy_2$, soluble by heat as K_3CoCy_6. **K_4FeCy_6** dirty green, changing to grey. **K_3FeCy_6** red-brown. With **C** and **Na_2CO_3**, reduced without fusion: no crust. With **borax**, blue.

18. **Nickel oxide NiO**, ash-grey; **hydrate** NiH_2O_2 unripe-apple green. Chief salt: Sulphate, faintly acid; bright green. **HCl** no reaction. **HCl + H_2S** no reaction. **NH_4HS**, black NiS,H_2O insoluble. **Na_2CO_3** pale green, insoluble basic carbonate. **$(NH_4)_2CO_3$** pale green, soluble. **KHO** apple-green hydrate. **NH_3**, apple-green hydrate, soluble to bright-blue solution; re-precipitates on boiling. **KCy**, yellowish-green $NiCy_2$, soluble as $2KCy,NiCy_2$. **K_4FeCy_6** yellowish-green. **K_3FeCy_6** greenish-yellow. With **C** and **Na_2CO_3**, reduced without fusion: no crust. With **borax** red-brown in outer, and grey in inner flame.

Thallium oxide Tl_2O; *vide* ante, p. 63.

19. **Manganous oxide MnO**, green; **hydrate** MnH_2O_2, white. Chief salts: Chloride and sulphate; faintly acid. Salts colourless, morning-red. **HCl** no precipitate. **HCl + H_2S** no precipitate. **NH_4HS**, flesh-coloured MnS,H_2O; by exposure, to brown Mn_2O_3,H_2O. **Na_2CO_3**, white $MnCO_3$. **KHO** white hydrate MnH_2O_2; by exposure, to brown Mn_2O_3,H_2O. **NH_3** white, like potash, but considerably soluble. If acid, no precipitate, but brown Mn_2O_3,H_2O by exposure. **K_3FeCy_6** brown. **K_4FeCy_6** white Mn_2FeCy_6. Heated on **C** with **Na_2CO_3**, reduced without fusion: no crust. On **platinum** with KNO_3 and Na_2CO_3, green manganate. With **borax**, in outer flame, amethystine; colourless in inner flame.

20. **Zinc-oxide ZnO**, white; **hydrate** ZnH_2O_2, white. Chief salt: White vitriol, $ZnSO_4,7H_2O$, feebly acid. **HCl** no precipitate. **HCl + H_2S** no precipitate. **NH_4HS**, white ZnS,H_2O, insoluble in KHO. **Na_2CO_3**, white $8ZnO,3CO_2,6H_2O$. **$(NH_4)_2CO_3$**, white, soluble. **KHO**, white hydrate; soluble. **NH_3**, white; soluble: no precipitate in acid solutions, or in presence of ammoniacal salts. K_4FeCy_6, white. K_3FeCy_6, yellowish-red. Heated on **C** with **Na_2CO_3**, Zn volatilized as ZnO, forming white crust, canary-yellow whilst red hot. Moistened with **Co_2NO_3** and heated on **C**, green. With **borax**, colourless bead.

21. **Aluminum oxide Al_2O_3**, white; **hydrate** $Al_2H_6O_6$. Chief salt: Alum; acid reaction. **HCl** no precipitate. **HCl + H_2S** no reaction. **NH_4HS**, white hydrate $Al_2H_6O_6$: *soluble* in **KHO**. **Na_2CO_3** white hydrate. **$(NH_4)_2CO_3$** white hydrate. **KHO** white hydrate; soluble. **NH_3** white hydrate. With **borax**, colourless. With **Co_2NO_3** on **C**, blue.

22. **Chromic oxide** Cr_2O_3, green; **hydrate** $Cr_2H_6O_6,4H_2O$, greenish-blue. Chief salt: Chrome-alum; purple or red, and acid reaction. **HCl** no precipitate. **HCl + H_2S** no precipitate. **NH_4HS** greenish-blue hydrate; soluble with green colour in KHO, and re-precipitated on boiling. **Na_2CO_3** greenish-blue hydrate. **KHO** greenish-blue, soluble to emerald-green, re-precipitated on boiling. **NH_3** greenish-blue hydrate; soluble in very large excess with rose colour. Heated on platinum with **KNO_3** and **Na_2CO_3** to yellow chromate. With **borax**, green in inner and outer flame. (**N.B.**—Chromic acids and soluble chromates are reduced by **HCl + H_2S** to chromic salt. *Vide* H_2CrO_4 ante, p. 67.)

IV. Metals not precipitated either by HCl, HCl+H_2S, or by NH_4HS: but by $(NH_4)_2CO_3$ even in presence of NH_4Cl.
Barium, Strontium, and Calcium: precipitated as Carbonates.

23. **Barium oxide BaO**, white; **hydrate** $BaH_2O_2,8H_2O$, also white. Chief salts: Nitrate and chloride. **HCl** no precipitate except in strong solutions of $BaCl_2$ or $Ba2NO_3$, then of $BaCl_2$ or $Ba2NO_3$, easily soluble in water. **HCl + H_2S** no precipitate. **NH_4HS** no precipitate. **NH_4Cl + $(NH_4)_2CO_3$**, white $BaCO_3$. **Na_2CO_3**, white $BaCO_3$. **KHO** white hydrate, soluble in 20 of H_2O. **NH_3**, none. **$CaSO_4$**, and all sulphates an *immediate* white $BaSO_4$, insoluble in acids. **$K_2Cr_2O_7$**, yellow $BaCrO_4$. **$2HF,SiF_4$**, white BaF_2,SiF_4. **Na_2HPO_4**, white Ba_32PO_4. On **platinum**, yellowish-green to outer flame. No colour to borax.

24. **Strontium oxide SrO**, white; **hydrate** $SrH_2O_2,8H_2O$, also white. Chief salts: Nitrate and chloride. **HCl** no precipitate. **HCl + H_2S**, none. **NH_4HS**. none. **NH_4Cl + $(NH_4)_2CO_3$**, white $Sr2CO_3$. **Na_2CO_3**, white $SrCO_3$. **KHO**, white hydrate, soluble in 50 of H_2O. **NH_3**, none. **$CaSO_4$**, white $SrSO_4$, only on *heating*, or long standing, *never immediately*. Soluble sulphates, white $SrSO_4$. **$K_2Cr_2O_7$**, no precipitate till heated. **$2HF,SiF_4$**, no precipitate. **Na_2HPO_4**, white Sr_32PO_4. On **platinum**, in outer flame crimson. No colour to borax.

25. **Calcium oxide** or **lime CaO**, white; **hydrate**, CaH_2O_2 white. Chief salts: Chloride, very soluble; sulphate but little. **HCl** no precipitate. **HCl + H_2S** no precipitate. **NH_4HS**, none. **NH_4Cl**, **+ $(NH_4)_2CO_3$** white $CaCO_3$. **Na_2CO_3** white $CaCO_3$. **KHO**, white hydrate, soluble in 778 of H_2O. **NH_3** no reaction. **$CaSO_4$**, of course none, but easily soluble sulphates, in solutions of $CaCl_2$, white $CaSO_4,2H_2O$. **Na_2HPO_4**, white Ca_32PO_4, soluble in acetic acid. On **platinum** in outer flame yellowish-red.

V. Metals not precipitated either by HCl,H_2S,NH_4HS or $(NH_4)_2CO_3$ in presence of Ammoniacal Salts. Magnesium, Ammonium, Lithium, Potassium, Sodium (Rubidium and Caesium).

26. **Magnesium oxide MgO** white; **hydrate** MgH_2O_2, white. Chief salts: Sulphate and chloride. **Na_2CO_3**, by degrees white $MgH_2O_2,2(MgCO_3,H_2O)$; immediately by boiling. **$NaHCO_3$**, when boiled, white basic carbonate: Na_2CO_3, slowly in the cold. **KHO** white hydrate. **BaH_2O_2, SrH_2O_2**, or **CaH_2O_2**, white hydrate, requiring 5142 of H_2O for solution. **NH_3** white hydrate; no precipitate in presence of free acid or ammoniacal salt. **Sulphates** none. **Na_2HPO_4** partially precipitates, but with NH_3 in presence of ammoniacal salts, white $MgNH_4PO_4,6H_2O$.

27. **Ammonia, NH_3**, or in solution NH_4HO. Salts volatile, colourless. Chief salts: Chloride, sulphate, nitrate, and sesquicarbonate. Solution of **NH_3** alkaline, with odour of hartshorn; fumes with HCl, blues red litmus. Volatile without residue. In salts. **Na_2CO_3** no precipitate, but odour of smelling salts, with distinctive reactions with glass-rod dipped in HCl, and with red litmus. **KHO** liberates NH_3. **CaH_2O_2** (as milk of lime) liberates NH_3. **$HCl + PtCl_4$**, yellow $2NH_4Cl,PtCl_4$. **$H_2C_4H_4O_6$**, in sols. of NH_3 and $(NH_4)_2CO_3$ crystalline $NH_4HC_4H_4O_6$. On **platinum**, volatile, except fixed acids.

28. **Lithium oxide L_2O**, white; **hydrate**, LHO, white. Salts colourless, purple to outer flame. Chief salts: Chloride and sulphate. **Na_2CO_3**, sparingly soluble L_2CO_3. **Na_2HPO_4**, precipitates L_3PO_4. On **platinum**, in inner flame, gives to outer purple colour.

29. **Potassium oxide K_2O; hydrate**, KHO white. Salts colourless, more or less fixed. Rose colour to flame. As soon as absence of ammoniacal salts determined: **$HCl + PtCl_4$** yellow. **$2KCl,PtCl_4$**, insoluble in mixed alcohol and ether. **$H_2C_4H_4O_6$** white, crystalline $KHC_4H_4O_6$. **$2HF,SiF_4$**, white $2KF,SiF_4$. **Carbazotic acid** yellow $KC_6H_2(NO_2)_3O$. On **platinum** in inner flame, tinge outer rose or violet.

30. **Sodium oxide Na_2O; hydrate** $NaHO$ white. Salts colourless, more or less fixed; orange colour to flame, and **all soluble** except **di-sodium antimonate** $Na_2H_2Sb_2O_7,6H_2O$. Consequently no precipitate by any test except **$K_2H_2Sb_2O_7,6H_2O$**, which is only useful when no other base present.

Tests for Acids.

A. Salts visibly or detectibly decomposed by HCl. As_2O_3 and B_2O_3 only in strong solutions.

1. **Carbonates.** Alkaline carbonates soluble; blue red litmus; bi-carbonates of alkaline earths into carbonates, and CO_2 by

boiling. **HCl** effervescence without disagreeable odour. **$BaCl_2$**, white $BaCO_3$, soluble as chloride in HCl. **Lime water**, white $CaCO_3$. **$AgNO_3$** white Ag_2CO_3 soluble in HNO_3 (as $AgNO_3$), and in NH_3. Solution of **H_2CO_3** faintly reddens litmus, evaporates without residue, odourless, precipitates lime-water; excess re-dissolves the precipitate.

2. **Sulphides.** Soluble sulphides are alkaline, odorous of H_2S. By **HCl**, H_2S evolved, and recognized by odour of putrid eggs, and blackening lead paper. In higher sulphides, S also deposited. **$FeSO_4$**, black FeS,H_2O. **$Pb2C_2H_3O_2$**, black PbS. Decomposed by HNO_3. Free H_2S recognized by odour, evaporation without residue, no reaction with H_2S, and metallic tests in acid solution.

3. **Sulphites.** Chief salt: Sulphite. Alkaline alone soluble, blue red litmus. Acid sulphites all soluble. **HCl** evolves SO_2 by heat, with odour of burning brimstone: if **Zn** added, H_2S free. **$BaCl_2$**, white $BaSO_3$ soluble in HNO_3 unless sulphate also present (generally the case). **$AgNO_3$**, white Ag_2SO_3 reduced by heat into $Ag_2 + H_2SO_4$. **Ferric** reduced to ferrous salts. **Free SO_2** known by odour; solution of H_2SO_3 evaporates without residue. $HCl + Zn$, yield H_2S. By **HNO_3** into H_2SO_4.

4. **Hyposulphites.** Chief salt: Sodium. Alkaline soluble. Blue red litmus. **HCl** precipitates S, solution becoming yellowish-white, and evolves SO_2. **$BaCl_2$**, white $BaS_2H_2O_4$. **$AgNO_3$**, white $Ag_2S_2H_2O_4$; decomposing into black Ag_2S and H_2SO_4. **$Na_2S_2H_2O_4$** dissolves AgCl as $NaAgS_2H_2O_4$.

5. **Arsenites.** Alkaline alone soluble. Colourless; blue red litmus. In concentrated solutions, **HCl** precipitates As_2O_3 white, and soluble in excess. $HCl + H_2S$, yellow As_2S_3, soluble in NH_3, in NH_4HS, and in $(NH_4)_2CO_3$. **$BaCl_2$** white, soluble in HCl. **$AgNO_3$**, yellow Ag_3AsO_3, soluble in HNO_3 and in NH_3. **$CuSO_4$**, green $CuHAsO_3$. Marsh's and Reinsch's tests, p. 64.

6. **Arsenates.** Chief salts: Sodium and potassium arsenates. *See* p. 64, among bases. **$HCl + H_2S$**, slowly prec. yellow $As_2S_3 + S_2$. **$AgNO_3$**, liver-brown Ag_3AsO_4. **$BaCl_2$**, white $Ba_{32}AsO_4$, soluble in HCl. **$CuSO_4$**, greenish-blue $CuHAsO_4$. Marsh's and Reinsch's tests.

7. **Silicates.** The soluble ones, strongly alkaline to test-paper. **HCl**, gelatinous H_4SiO_4 deposited, rendered quite insoluble by evaporation to dryness; infusible: with **Na_2CO_3** on **platinum** wire, forms a glass.

8. **Borates.** Alkaline soluble, fusible; insoluble, dissolved by acids and ammoniacal salts. Chief salt, Borax. **HCl** in strong solutions precipitates $B_2O_3,3H_2O$ in scales. **$BaCl_2$** white $Ba2BO_2$ soluble in HNO_3 or HCl. **$AgNO_3$** white $AgBO_2$ soluble in NH_3 and HNO_3. **$CaCl_2$** white $Ca2BO_2$, soluble in HNO_3. Free $B_2O_3.3H_2O$ fusible, fixed in flame. Gives green colour to flame.

Borates also, when moistened with H_2SO_4.—N.B. Residues on platinum should always be thus heated for boracic acid.

9. **Chromates.** Solutions yellow or red: alkaline and bichromates soluble. Chief salt: $K_2Cr_2O_7$. Neutral, turned into acid, by HCl, with deepening of colour. **HCl** + **H_2S** into green salts of Cr_2O_3. **$BaCl_2$** yellow $BaCrO_4$ soluble in HNO_3. **$AgNO_3$** crimson Ag_2CrO_4. $Pb2C_2H_3O_2$ yellow $PbCrO_4$, soluble in KHO. **Alcohol** and HCl reduces H_2CrO_4 to green or violet salts of Cr_2O_3.

10. **Chlorates.** Chief salt: $KClO_3$. All salts soluble. Deflagrate on charcoal. On **Platinum** into **chlorides**, which are precipitated white by $AgNO_3$, insoluble in HNO_3 but soluble in NH_3. **HCl** on heating, change colour to yellowish-green, evolving $2Cl_2O_5$, Cl_2O_3, and Cl_2. When free from sulphates and chlorides, no precipitates by $BaCl_2$ and $AgNO_3$.

11. **Hypochlorites,** always contain chlorides. Solutions bleach. Evolve by **HCl** either HClO or Cl_2, according to quantity of HCl employed.

12. **Iodates.** Alkaline soluble. Deflagrate on charcoal. **Heated,** into iodides. **HCl** changes colour by liberating I_2, detected by heat and starch on glass rod. **H_2S** reduces to iodides. **$BaCl_2$** white $Ba2IO_3$, soluble in HNO_3. **$AgNO_3$** white $AgIO_3$, soluble in HNO_3 and NH_3.

13. **Cyanides.** Soluble, have an alkaline reaction, with odour of prussic acid. By **HCl** decomposed, with increased odour of HCy. **$BaCl_2$** no precipitate. **$AgNO_3$** white AgCy, easily soluble in KCy, sparingly in NH_3 and only in strong HNO_3. AgCy is decomposed by HCl into AgCl + HCy. AgCy heated, evolves Cy_2. Further tests. Boil with **KHO** in excess and **$FeSO_4$** and then add **HCl**: Prussian blue $Fe_4Fe_3Cy_{18}$ is formed. Boil fresh portion with **$(NH_4)_2S_2$**, till only NH_4Csy remains; then add **Fe_2Cl_6**; blood-red **Fe_2Csy_3**. **HCy** volatile, with strong odour; precipitates $AgNO_3$ where vapours meet it. Add KHO first, in testing by $FeSO_4$. **Ferrocyanides, ferricyanides,** and **sulphocyanides,** p. 74.

B. Precipitated by Barium chloride. Includes most of those already enumerated, as well as:

14. **Sulphates.** All soluble except $BaSO_4$, $SrSO_4$, and $PbSO_4$. $CaSO_4$, $2H_2O$ with difficulty. **HCl** no reaction. **HCl**+**H_2S** none. **$BaCl_2$** white $BaSO_4$, insoluble in HNO_3. **$Pb2C_2H_3O_2$** white $PbSO_4$. By **fusion** with **Na_2CO_3** on **C**, sulphide formed, which, if moistened on Ag, blackens the latter: by HCl, H_2S evolved. Free **H_2SO_4** oily liquid, heats with H_2O, volatilizes on platinum with white, stifling, acid fumes.

15. **Phosphates.** Alkaline **ortho-phosphates** soluble, **HCl** no visible reaction. **HCl** + **H_2S** none. **$BaCl_2$** white $BaHPO_4$ soluble in HNO_3. **$AgNO_3$** yellow Ag_3PO_4, soluble in HNO_3 and

NH_3. **$Pb2C_2H_3O_2$**, white $Pb_3 2PO_4$ insoluble in $HC_2H_3O_2$ and NH_3. **Fe_2Cl_6** white $FePO_4$ insoluble in $HC_2H_3O_2$. **$MgSO_4$ + NH_4Cl + NH_3**, white, crystalline $NH_4MgPO_4.6H_2O$. **Pyrophosphates** by boiling with H_2SO_4, into orthophosphoric acid. Pyrophosphates precipitate **$AgNO_3$** as white $Ag_4P_2O_7$ soluble in HNO_3 and in NH_3. **Metaphosphates**, also, by boiling with H_2SO_4, into orthophosphoric acid. **$AgNO_3$** white, gelatinous $AgPO_3$, soluble in $NaPO_3$. **$BaCl_2$** white $Ba2PO_3$. On adding **$HC_2H_3O_2$** to a soluble metaphosphate, albumen coagulated.

16. **Oxalates.** Heated on platinum: ammonium salts volatilized, others decomposed, either into carbonates without blackening, or reduced. **HCl** produces no visible reaction. **HCl + H_2S** none. **$BaCl_2$** white BaC_2O_4 soluble in HCl and HNO_3. **$AgNO_3$**, white $Ag_2C_2O_4$ soluble in NH_3 and in HNO_3. **$Pb2C_2H_3O_2$**, white PbC_2O_4. **$CaCl_2$** white CaC_2O_4, insoluble in $HC_2H_3O_2$. Dry oxalates with H_2SO_4 evolve $CO + CO_2$, the former gas burning with blue flame. Free $H_2C_2O_4,2H_2O$ in 4-sided, colourless prisms, acid, soluble, decomposed and volatilized by heat without blackening. Precipitates lime water, and even solution of $CaSO_4$.

17. **Citrates.** Alkaline, soluble, colourless. By **heat** fusible, and decomposed into carbonates, emitting pungent fumes with separation of **C**. **HCl** no visible result. **HCl + H_2S** none. **$BaCl_2$** white $Ba_3 2C_6H_5O_7$ soluble in HCl and HNO_3. **$AgNO_3$** white $Ag_3C_6H_5O_7$ soluble in NH_3 and HNO_3. **$Pb2C_2H_3O_2$** white $Pb_3 2C_6H_5O_7$, soluble in HNO_3. **$CaCl_2$** white $Ca_3 2C_6H_5O_7$, insoluble in KHO, readily in NH_4Cl; re-precipitated on boiling. Free **$H_3C_6H_5O_7,H_2O$** transparent, rhombic prisms, very soluble. Decomposed by heat: coaly residue burns away. No precipitate with $CaCl_2$ or with **lime-water** in excess, **until boiled.** With H_2SO_4 at 38°C. yields pure CO.

18. **Tartrates.** Fuse, and carbonize, emitting **odour** of burnt sugar; carbonates of the fixed alkalies and alkaline earths remain. Chief salt: $KHC_4H_4O_6$, little soluble, acid to test-paper, easily dissolved by acids. Solution of neutral tartrate $K_2C_4H_4O_6$, precipitated by **HCl** as $KHC_4H_4O_6$. In neutral salts: **$BaCl_2$** white $BaC_4H_4O_6$, soluble in HCl and HNO_3. **$AgNO_3$**, white $Ag_2C_4H_4O_6$ soluble in NH_3 and HNO_3. **$CaCl_2$** white $CaC_4H_4O_6$, soluble **when washed** in KHO, also in NH_4Cl and in $HC_2H_3O_2$. —Free **$H_2C_4H_4O_6$**, in transparent, oblique-rhombic prisms. By heat decomposed: coaly residue burns away. **KHO**, if the acid be in excess, precipitates $KHC_4H_4O_6$ soluble in excess of KHO. **NH_3** precipitates $NH_4HC_4H_4O_6$ soluble in excess of NH_3.

C. Not precipitated by Barium Chloride, but by Argentum Nitrate.

19. **Chlorides.** Soluble, colourless salts. Insoluble are: Hg_2Cl_2; AgCl with difficulty, $PbCl_2$ and TlCl. Some volatile. **HCl** no reaction.—N.B. **HCl** precipitates a solution of $BaCl_2$, as

$BaCl_2$, little soluble in HCl but soluble in H_2O.) **HCl** + H_2S none. $BaCl_2$ none. **$AgNO_3$** white AgCl; soluble in NH_3 and insoluble in HNO_3. **$Hg_2 2NO_3$** yellowish-white Hg_2Cl_2, blackening by NH_3. **$Pb2C_2H_3O_2$** white, soluble in 35 parts of boiling H_2O. **MnO_2** + $2H_2SO_4 = Cl_2$, known by colour, odour, and bluing starch in KI solution.—Free **HCl**, acid, volatile without residue, &c. HNO_3 gives fumes of $NOCl_2 + Cl_2$.

20. **Bromides.** Much like chlorides, but decomposed by **Cl_2** with orange colour of Br. **$AgNO_3$** yellowish-white AgBr; when washed soluble in much NH_3, insoluble in HNO_3. **$Hg_2 2NO_3$** yellowish-white Hg_2Br_2. **$Pb2C_2H_3O_2$** white, insoluble in H_2O. **HNO_3** *by heat*, red-brown vapours and drops of Br.—Free **HBr** acid, volatile without residue: HNO_3 liberates Br.

21. **Iodides.** Like chlorides, but several coloured. Decomposed by **Cl_2**. **$AgNO_3$** yellowish AgI; when washed, insoluble in NH_3 and in HNO_3. **$Hg_2 2NO_3$** green Hg_2I_2. **$HgCl_2$** scarlet HgI_2, soluble in excess. **$Pb2C_2H_3O_2$** yellow PbI_2, soluble in much hot water. **HNO_3** liberates solid I; by heat, violet vapour, blues starch. **$PtCl_4$** deep brown-red PtI_4. Free **HI** volatile; generally deep-brown, from presence of iodine in solution.

Cyanides already described. Decomposed by HCl.

22. **Ferrocyanides.** Alkaline soluble. $K_4FeCy_6,3H_2O$ chief salt: lemon-yellow. **HCl**, concentrated, precipitates bluish-white H_4FeCy_6. **$AgNO_3$** white Ag_4FeCy_6. **$FeSO_4$** (if free from per salt, else bluish or blue) greenish-white $KFeCy_3$. **Fe_2Cl_6** Prussian blue $Fe_4Fe_3Cy_{18}$. Most ferrocyanides insoluble.

23. **Ferri-cyanides.** Alkaline soluble; K_3Cdfy chief salt, red. **HCl** no visible reaction. **$AgNO_3$**, deep orange Ag_3Cdfy. $Hg_2 2NO_3$ brownish-red $Hg_3 2Cdfy$. **$FeSO_4$**, Turnbull's blue $Fe_3 2Cdfy$. **Fe_2Cl_6** browns.

24. **Sulpho-cyanides,** mostly soluble salts. Chief salt KCNS or KCsy. **HCl** no visible reaction. **$AgNO_3$** white AgCsy soluble in NH_3 and in HNO_3. **$Hg_2 2NO_3$** white Hg_2Csy_2. **Fe_2Cl_6** blood-red colour, discharged by $HgCl_2$. With **Zn** + **HCl**, H_2S free.

25. **Acetates.** Mostly colourless and soluble. By heat, acetates of fixed alkalies and alkaline earths into carbonates, without blackening. **HCl** no visible reaction. **$AgNO_3$** in strong solutions, white crystalline $AgC_2H_3O_2$ soluble in NH_3 and HNO_3. **$Hg_2 2NO_3$** white, silken scales of $Hg_2 2C_2H_3O_2$. **Fe_2Cl_6** imparts deep-red colour. **H_2SO_4** and **C_2H_6O** by heat, evolve ACETIC ETHER $C_2H_5,C_2H_3O_2$. Free ACETIC ACID **$HC_2H_3O_2$**, volatile acid, with odour of vinegar; no residue. Calcium acetate very soluble.

D. Not precipitated by Barium Chloride or Argentum Nitrate. All salts soluble.

26. **Nitrates.** Colourless salts, deflagrate on **charcoal.** KNO_3 chief salt; changed by red-heat into KNO_2. **KNO_3** forms green

$Cu2NO_2$ with $CuSO_4$ and gives off fumes of N_2O_3 when heated with H_2SO_4. These are the chief tests for **nitrites**. **HCl**, **H_2S**, **$BaCl_2$** and **$AgNO_3$** no reaction. **H_2SO_4** liberates HNO_3: with **Cu** + **H_2SO_4** orange vapours of NO_2 and with **$FeSO_4$** + **H_2SO_4** olive-brown $2FeSO_4,NO$, decomposed by heat with evolution of NO_2. —N.B. Free **HNO_3** acid, volatile without residue; HCl liberates Cl_2 and $NOCl_2$.

Chlorates. Already detected by heating with HCl.

ORGANIC CHEMISTRY.

INTRODUCTION.—Chief zoötic elements: Carbon, Hydrogen, Oxygen, Nitrogen, Sulphur, and Phosphorus. Organic bodies usually blacken on the application of heat, and evolve H_2O. **Organic Analysis.** **C** and **H** by complete combustion, collecting and weighing the products: **CuO** the oxidizing agent. **N** determined by heating with soda-lime and collecting the NH_3 in HCl. **N** estimated from $2NH_4Cl,PtCl_4$. The NH_3 can also be collected in a measured quantity of a standard collection of $H_2C_2O_4$. **O** by the loss. **S** and **P** by fusion with 10 of KNO_3, 2 of Na_2CO_3, and 30 of pure NaCl: the S and P oxydized to SO_3 and P_2O_5, which combine with portion of the alkali.—If **As** present, it also oxydized to As_2O_5. **Cl** by heating with 10 parts CaO: $CaCl_2$ produced, and Cl weighed as AgCl. **Br** and **I** by same method. **Chemical formulæ.** EMPIRICAL and RATIONAL. The EMPIRICAL formulæ deduced from the per-centage composition. Thus, SUGAR is composed of 41.98 **C**, 6.43 **H**, and 51.59 **O**; if divided by the combining proportion, the quotients will signify the relations between them, and these must be reduced to the simplest expressions. A RATIONAL formula requires a knowledge of its combining proportion, and may either agree with the empirical, or be a multiple of the latter. Thus the empirical formula for ACETIC ACID is CH_2O, but its rational is $C_2H_4O_2$ or $HC_2H_3O_2$, because it contains an atom of displaceable hydrogen. **Isomerism**: identity of ultimate composition, with difference in chemical properties. When the eqs. identical, isomerides said to be **metameric** as $HC_2H_3O_2$; $CH_3,C_2H_3O_2$ and C_2H_5,CHO_2. When this is not the case the state of condensation supposed to be different, **polymeric**. CH_2; C_2H_4; C_3H_6; C_4H_8 are polymeric. Bodies which stand related to each other like the alcohols, or which differ only by a multiple of CH_2, are called **homologous**: all such, when treated by the same chemical agents, furnish others, different, yet standing in a fixed relation: **heterologous**. In homologous bodies, COMPOUND RADICALS, supposed to exist as METHYL **CH_3** in METHYLIC ALCOHOL **$(CH_3)HO$**. Compound types of Laurent and Gerhardt. Distinction between

atoms and **molecules**: the atom the smallest particle in a compound, incapable of separate existence: the molecule the smallest quantity of an element in a separate state and must consist of at least two atoms. As a rule, the molecules of all compound bodies capable of vaporization occupy two volumes. Four principal types:

$$\left.\begin{matrix}H\\H\end{matrix}\right\}\text{or } H_2;\ \left.\begin{matrix}H\\H\end{matrix}\right\}O \text{ or } H_2O;\ \left.\begin{matrix}H\\H\\H\end{matrix}\right\}N \text{ or } H_3N \text{ and } \left.\begin{matrix}H\\H\\H\\H\end{matrix}\right\}C \text{ or } H_4C.$$

The amylaceous group: Includes **Starch, Sugar,** and **allied bodies.** STARCH $C_6H_{10}O_5$; fecula or amylum, in flattened, rounded (angular in rice) grains; in the seeds of leguminosæ; in the cellular tissue of plants; in the cereals, and varying in size from $\frac{1}{360}''$ in tous les mois, to $\frac{1}{80}''$ in arrow-root, $\frac{1}{1000}''$ in wheat, and $\frac{1}{3000}''$ in rice. Potatoes 20, wheat 60, and rice about 83 per cent. White, glistening insoluble in and heavier than H_2O: insoluble also in alcohol and ether. Heated in H_2O above 60°C., the granules smell and become pasty. Blue colours with iodine. Hygroscopic. Precipitated by ammoniacal plumbum acetate as $2PbO, C_{12}H_{18}O_9$ and partially by tannin. At 204°·5C. starch turned to DEXTRINE $C_6H_{10}O_5$, isomeric with starch. Transparent, yellowish, brittle solid, soluble in H_2O (British gum) and dilute spirit: rotates polarized ray to the right (dexter), its rotary power being + 138°7. No blue compound with I: does not reduce alkaline tartrate of copper. Varieties of starch. *Sago* from the pith of a palm. *Tapioca* from Iatropha manihot. *Salep* from Orchis mascula. *Arrow-root* from Maranta arundinacea. GLYCOGEN $C_6H_{10}O_5$ in the liver of pigs, white, starch-like, soluble in H_2O, insoluble in alcohol. INULIN $C_6H_{10}O_5$ at 100°C. In Inula, Leontodon, Colchicum, Cichoreum, Dahlia, &c.; white, tasteless, insoluble in alcohol, sparingly in cold, easily in boiling H_2O. ARABIN $2(C_6H_{10}O_5),H_2O$ in gum arabic. Transparent, tasteless, easily soluble in H_2O. Unfermentable. Precipitated by alcohol and ether. By dilute H_2SO_4 into sugar. By ammoniacal plumbum acetate, pr. as $PbO,3C_6H_{10}O_5$. By HNO_3, into mucic and oxalic acids. Mucilage in linseed, &c., soluble in H_2O and pr. by neutral $Pb2C_2H_3O_2$. BASSORIN in gum tragacanth, not soluble, but softens in H_2O: CERASIN resembles it. PECTIN $C_{32}H_{40}O_{28},4H_2O$, is the jelly of fruits, soluble in H_2O, insoluble in C_2H_6O. Treated with alkalies, into PECTIC ACID $H_2C_{16}H_{20}O_{15}$ gelatinous. Pectates of alkalies alone soluble. By long boiling, pectic into PARAPECTIC ACID $H_4C_{24}H_{20}O_{23}$; by alkalies, parapectic into METAPECTIC ACID $H_4C_6H_{10}O_9$. PECTOSE, not gelatinous; in turnips, carrots, &c.; insoluble in H_2O. CELLULOSE $C_{18}H_{30}O_{15}$; basement tissue of vegetables. Porous in pith; dense in vegetable ivory, &c. Tasteless, insoluble, digestible when suc-

culent; by H_2SO_4 into dextrin and glucose. Digested for a short time with H_2SO_4 blues I. Cellulose (as cotton) by HNO_3, into PYROXYLIN, TRI-NITRO-CELLULIN, or GUN-COTTON $C_{18}H_{21}(NO_2)_9O_{15}$; white, fibrous, insoluble in H_2O and C_2H_6O. The alkaline solution reduces ammonium-silver nitrate. Also soluble in alkalies; in mixed alcohol and ether, forming Collodion. Non-conductor of electricity. Ignites at 150°C.: to H_2O, N_2, CO_2, CO, CH_4, and NO. LIGNINE the encrusting matter of the cells, hard and indigestible. More H than cellulose: blackened by H_2SO_4. Decay of woody fibre. GEIC ACID $C_{20}H_{12}O_7$. HUMIC ACID $C_{20}H_{12}O_6$. ULMIC ACID $C_{20}H_{14}O_6$. Besides these: CRENIC ACID $H_6C_{24}H_{24}O_{19}$ and APOCRENIC ACID $H_2C_{24}H_{12}O_{13}$. All greedily retain NH_3 in soils. **The sugars.** SUCROSE or CANE-SUGAR $C_{12}H_{22}O_{11}$ in *Saccharum officinarum.* As sugar candy in 4-sided, oblique-rhombic prisms, with dihedral summits. Sp. gr. 1.696. Soluble in ⅓ of cold H_2O. Its specific power of rotation 73°8′. Sugar melts at 160°C.; barley-sugar is amorphous. At 218°.5C. into CARAMEL $C_{12}H_{18}O_9$. Sugar is antiseptic. Fattening. Acid by boiling, into: FRUCTOSE or LÆVULOSE $C_6H_{12}O_6$; uncrystallizable; less sweet. Does not reduce alkaline salts of CuO; with lime to soluble $CaO,C_{12}H_{22}O_{11}$ and insoluble $3CaO,C_{12}H_{22}O_{11}$; hence syrup, a good wash for lime in the eyes. With lead-oxide, $PbO,C_{12}H_{20}PbO_{11}$; loses H_2O when dried at 100°C. With NaCl $(2NaCl,C_{12}H_{20}O_{10},C_{12}H_{22}O_{11}$. Reduces H_2CrO_4 to Cr_2O_3; HgO salts to Hg_2O. By H_2SO_4 into C, containing Ulmic acid, CO_2, and a little Formic acid. By dilute HNO_3, of sp. gr. 1.27, at a temperature not above 70°C., into SACCHARIC ACID $H_2C_6H_8O_8$ and CO_2; by stronger acid into OXALIC ACID $H_2C_2O_4,2H_2O$. FRUCTOSE or LÆVULOSE $C_6H_{12}O_6$; in honey and manna; grapes, cherries, and figs. Mixed with sucrose in apricots, peaches, strawberries, plums, &c. Called inverted sugar, because it produces left-handed rotation = −106° at 13°C. SORBIN $C_6H_{12}O_6$, in *Sorbus aucuparia* berries, is isomeric; it is not, however, fermentable. DEXTROSE, GLUCOSE or GRAPE-SUGAR $SC_6H_{12}O_6,H_2O$ in dried fruits, crystallizes with difficulty in cubes, less soluble, and scarcely one-third as sweetening as cane-sugar. Artificially from starch, dextrine, dextrose, cellulose, and sucrose. More soluble in alcohol. Contained in candied raisins; in the blood, white of egg, and urine normally; in diabetes abnormally. Produces right-handed rotation = + 57°4′. Softens at 60°C., melts at 100°C., and becomes $C_6H_{12}O_6$; at 140°C. into Caramel. Reduces alkaline cupric salts to subsalts. Reduces also salts of Ag, Hg, and Au. Heated with KHO, browns from formation of MELASSIC ACID. By H_2SO_4 into Sulpho-saccharic acid. Ferments with yeast. With Sodium chloride $(NaCl,H_2O,2C_6H_{12}O_6)$. [MELITOSE $C_{12}H_{24}O_{12},2H_2O$ in the manna of Eucalyptus. MANNITE $C_6H_{14}O_6$ in manna from *Fraxinus ornus;* in celery, onions,

asparagus. From manna by boiling alcohol. Silken prisms, very soluble in H_2O; of sickly taste. Does not brown by alkalies, nor reduce cupric salts; does not blacken with H_2SO_4. Like Arabin by HNO_3, into mucic acid. ERYTHRITE $C_4H_{10}O_4$ from *Rocella* and other Lichens. DULCITE $C_6H_{14}O_6$. QUERCITE $C_6H_{12}O_5$ in acorns. PINITE $C_6H_{12}O_5$ from *Pinus Lambertiana*. GLYCYRRHIZIN $C_{24}H_{36}O_9$ in liquorice. Sweet, very soluble in H_2O and alcohol. Not fermentable.] LACTOSE or SUGAR OF MILK $C_{12}H_{24}O_{12}$. White, translucent, 4-sided prisms of great hardness. Sp. gr. 1.543. Soluble in 5 or 6 of H_2O; insoluble in alcohol and ether. Produces right-handed rotation $=56°4'$. Reduces cupric salts. Heated to 140°C. loses 1 molecule of H_2O, at 204·5°C. 2½ molecules. By dilute H_2SO_4 into glucose: forms a crimson solution with H_2SO_4. Excess of HNO_3 into MUCIC ACID $C_6H_{10}O_8$, isomeric with SACCHARIC ACID from cane and grape-sugar. Not directly fermentable.

Polybasic vegetable acids. 1. OXALIC ACID $H_2C_2O_4.2H_2O$. In Oxalis and Rumex as potassium binoxalate. Prepared from starch and sugar by oxydation. Thus: $C_6H_{10}O_5+9HNO_3 = 9HNO_2+2H_2O+3H_2C_2O_4$. Also, from sawdust by action of $2NaHO+KHO$ and heat: the acid made from $Na_2C_2O_4$, which is but little soluble. In 4-sided oblique-rhombic prisms, soluble in 8 of cold and 1 of boiling H_2O. Acid: poisonous. Antidotes: chalk or magnesia, at 100°C. loses 28½ per cent. of H_2O; by rapid heat at 160°C. into CO_2+H_2O+ FORMIC ACID $HCHO_2$. Leaves no carbonaceous residue. OXALATES: POTASSIUM $K_2C_2O_4,H_2O$ in rhombic prisms, soluble in 3 of water. KHC_2O_4,H_2O is salt of sorrel. Requires 40 of cold H_2O. $Na_2C_2O_4$ little soluble. $(NH_4)_2C_2O_4,H_2O$ in colourless prisms; chief test for calcium. By heat, OXAMIDE $C_2H_4N_2O_2$, is left. $NH_4HC_2O_4$, H_2O much less soluble. $CaC_2O_4,2H_2O$, insoluble in H_2O and acetic acid: by heat into $CaCO_3$. Metallic oxalates sparingly soluble. Oxalic acid reduces $AuCl_3$. Thus: $2AuCl_3+3H_2C_2O_4=6HCl+6CO_2+Au_2$. Oxalic acid contains the dyad radical C_2O_2. [MELLITIC ACID $H_2C_4O_4$ in Mellite (a yellow salt occurring in lignite), as mellitate of alumina. From alcohol in needles. Soluble in H_2O, not decomposed by H_2SO_4 or HNO_3, but by red heat into C and a crystalline sublimate. RHODIZONIC ACID $H_2C_6HO_6$ formed by the action of H_2O on the compound of K_2 and CO obtained in the manufacture of K_2. Salts red. CROCONIC ACID $H_2C_5O_5,3H_2O$, yellow crystals, soluble in H_2O and alcohol.]

2. TARTARIC or DEXTRO-RACEMIC ACID $H_2C_4H_4O_6$; in grapes, as cream of tartar; in pines, tamarinds, the unripe berries of mountain-ash, &c. Di-basic acid in colourless, transparent, oblique-rhombic prisms; very soluble. In solution, it moulds; acetic acid being formed. Fuses at 170°C.: quickly heated, it

carbonizes and emits odour of burnt sugar. Reduces salts of Ag, Au, and Pt. Heated with potash: $H_2C_4H_4O_6 + 3KHO = KC_2H_3O_2 + K_2C_2O_4 + 3H_2O$. Boiled with lead peroxide: $H_2C_4H_4O_6 + 3PbO_2 = Pb2CHO_2 + 2PbCO_3 + 2H_2O$. *Prep.* Of the acid from cream of tartar: $2KHC_4H_4O_6 + CaCO_3 = CaC_4H_4O_6 + K_2C_4H_4O_6 + CO_2 + H_2O$. Then: $K_2C_4H_4O_6 + CaCl_2 = 2KCl + CaC_4H_4O_6$. Finally: $CaC_4H_4O_6 + H_2SO_4 = CaSO_4 + H_2C_4H_4O_6$. Heated to 190°C. into TARTRALIC ACID $H_4,H_2(C_4H_2O_2)_2O_7$. TARTRATES. **$KHC_4H_4O_6$** is argol or tartar. Requires 180 parts of cold and 6 of boiling H_2O. By heat into black flux: $K_2CO_3 + C$. Calcined with nitre into white flux K_2CO_3. **$K_2C_4H_4O_6$** in right-rhombic prisms very soluble. **$KNaC_4H_4O_6$, $4H_2O$** is Rochelle salt; large, transparent, 6-sided prisms, soluble in $1\frac{1}{2}$ of H_2O. **$NH_4HC_4H_4O_6$** resembles tartar. **$K,FeO,C_4H_4O_6$** and **$NH_4,FeO,C_4H_4O_6$** used in medicine. **$2(K,SbO,C_4H_4O_6),H_2O$** is tartar emetic. In octohedra with rhombic base, soluble in 15 of cold and 3 of boiling water. 3. PARA-TARTARIC OR RACEMIC ACID **$H_2C_4H_4O_6,H_2O$** is metameric. Found in the grapes of the Vosges. Precipitates solutions of $CaSO_4$ and $CaCl_2$, which property is not possessed by tartaric acid. 4. CITRIC ACID **$H_3C_6H_5O_7,H_2O$**. In *Citrus medica* or Lime, in lemons, &c. Tri-basic acid, in transparent rhombic prisms, very soluble in H_2O. Heated to 100°C., the crystals melt and lose H_2O; at 155°C., pure CO_2 evolved. At 177°C., into H_2O, CO, CO_2, and ACETONE C_3H_6O; while ACONITIC ACID $H_3C_6H_3O_6$ remains as a brown residue. Lime-water in excess, no precipitate till boiled. By H_2SO_4 at 38°C., gives pure CO. By HNO_3 into acetic, oxalic, and carbonic acids. With potash: $H_3C_6H_5O_7 + 4KHO = 2KC_2H_3O_2 + K_2C_2O_4 + 3H_2O$. CALCIUM CITRATE **$Ca_3,2C_6H_5O_7$, $4H_2O$** even less soluble in boiling than cold H_2O; the acid made from this salt by $H_2SO_4,2H_2O$. 5. MALIC ACID **$H_2C_4H_4O_5$** in *Prunus malus, &c.* Di-basic, deliquescent. Heated to 180°C. into water, volatile MALEIC ACID $H_2C_4H_2O_4$ and little soluble FUMARIC ACID $H_2C_4H_2O_4$; both isomeric. Thus: $2H_2C_4H_4O_5 = 2H_2O + H_2C_4H_2O_4 + H_2C_4H_2O_4$. Fused with KHO; $H_2C_4H_4O_5 + 3KHO = H_2 + 2H_2O + K_2C_2O_4 + KC_2O_3O_2$. MALATES. **$NH_4HC_4H_4O_5$** in right rhombic prisms. By heat into FUMARIMIDE $C_4H_3NO_2 + 3H_2O$. **$CaH_2,2C_4H_4O_5,8H_2O$** in transparent, rhombic prisms, sparingly soluble. In tobacco. **$CaC_4H_4O_5,2H_2O$** by evaporation at ordinary temperatures in brilliant scales. But, when solution is boiled for some hours, in form of a granular salt with one of H_2O. LEAD MALATE **$Pb2C_4H_4O_5,3H_2O$**. Little soluble, almost fusing under boiling H_2O. From this salt, the acid by H_2S or H_2SO_4. Amide of malic acid, ASPARAGINE $C_4H_8N_2O_3$, H_2O, in Asparagus. Heated with alkalies into NH_3 + ASPARTIC ACID $HC_4H_8NO_4$. 6. MECONIC ACID **$H_3C_7HO_7,3H_2O$**, in the juice of poppy (μήκων). Tribasic, astringent, sparingly soluble in

cold H_2O. Soluble in alcohol, ether, and boiling water. Its solution when boiled into COMENIC ACID $H_2C_6H_2O_5 + CO_2$. MECONATES. $Ca_2 2C_7HO_7$. $Pb_2 2C_7HO_7$ almost insoluble. The acid from the one by HCl, the other by H_2S. Tests. Precipitate by $Pb_2C_2H_3O_2$ in suspected poison-cases, decompose $Pb_2 2C_7HO_7$ by $3H_2S$, concentrate below 70°C. and add Fe_2Cl_6. A deep red colour, not bleached by $HgCl_2$ or $AuCl_3$ nor by Zn and dilute H_2SO_4. 7. GALLO-TANNIC ACID OR TANNIC ACID $C_{27}H_{22}O_{17}$; in the tannin of galls from *Quercus infectoria*. From gall-nuts by aqueous ether; tannic acid in the H_2O, gallic acid in the ether. Pale yellow, amorphous; reddens litmus; decomposes carbonates. Very soluble in H_2O, and dilute alcohol, sparingly in ether. Precipitates salts of morphin, &c., hence more or less an antidote to poisoning by alkaloids. Precipitated by H_2SO_4, HCl, H_3PO_4, &c. By gelatine as insoluble TANNO-GELATIN (leather). Ferric salts, bluish-black per-tannate, the basis of *ink*. Boiled with acids: $C_{27}H_{22}O_{17} + 4H_2O$ = GALLIC ACID $3H_3C_7H_3O_5 + C_6H_{12}O_6$. Heated to 215°C., H_2O and CO_2 are evolved, with formation of pyrogallic and metagallic acids. Many plants contain tannin: it is the astringent principle of tea and coffee. The tannin of cinchona bark, which contains both quino-tannic acid and KINIC ACID or QUINIC ACID $HC_7H_{11}O_6$; differs from that of fustic. Kino, divi-divi, and catechu are varieties of tannin. Catechin from catechu, in needles, does not precipitate gelatin, the alkaloids, or starch. 8. GALLIC ACID $H_3C_7H_3O_5.H_2O$. About 3 per cent. in gall-nuts. Artificially by mixing pounded galls with H_2O into a paste, and exposure to air for 6 or 8 weeks at 38°C. Tri-basic acid; in silken, yellowish-white needles, soluble in 100 of cold and 3 of boiling H_2O. Does not precipitate gelatin: blue-black colour with ferrous salts. Reduces Au and Ag salts. At about 215°C into CO_2 and PYROGALLIC ACID. Thus: $H_3C_7H_3O_5 = C_6H_6O_3 + CO_2$. ELLAGIC ACID $HC_7H_2O_4.H_2O$ formed in preparation of $H_3C_7H_3O_5$. Soluble in alkalies. Insoluble in H_2O. PYRO-GALLIC ACID or PYROGALLIN $C_6H_6O_3$. In shiny scales, soluble in H_2O, C_2H_6O, and $C_4H_{10}O$. Reddens litmus. Reduced salts of Au and Ag, used in photography. Melts at 115°C. At 250°C. into H_2O and METAGALLIC ACID $C_6H_4O_2$. Thus: $C_6H_6O_3 = C_6H_4O_2 + H_2O$. Purple colour with milk of lime, a red colour with ferric, and a blue with ferrous salts. Potassium pyrogallate with KHO is a test for free O_2, and may be employed in its estimation: browns immediately in its presence.

The Alcohols. Mono-basic Alcohols.

1. METHYLIC ALCOHOL, CH_3HO. From destructive distillation of hard wood: hence Pyroxylic spirit and wood-naphtha. Also in oil of *Gaultheria procumbens*. Colourless liquid, of penetrating

odour, inflammable and volatile. Sp. gr. of liquid at 0°C., 0.8142. Boils at 65°.5 C. Miscible with H_2O: solvent of resins. Alkalies dissolve and colour it brown (Ure's test). By oxydation: $CH_3HO + O_2 = H_2O +$ FORMIC ACID $HCHO_2$. Other reactions: $CH_3HO + NaHO$ by heat $= NaCHO_2 + 2H_2$. Again: $2CH_4O + 2KHO = K_2C_2O_4 + 5H_2$. Formed artificially by Berthelot, thus: $CH_3Cl + KHO = KCl + CH_3HO$. 2. ETHYLIC ALCOHOL $\mathbf{C_2H_5HO}$. As absolute alcohol, colourless, volatile, of strong spirituous odour: inflammable. Sp. gr. of liquid at 0° C. 0.8095, and at 15°.5 C. 0.794. Never frozen. Viscid at −110° C. Boils at 78°.4 C. Great affinity for H_2O. A solvent of gases, deliquescent salts (*but not of* K_2CO_3), the alkalies, I (forming tincture of iodine), Br, of resins (varnishes); (the Excise allow the use of it, mixed with $\frac{1}{10}$ of methylic alcohol), essential oils (eaux de), alkaloids. Fats and fixed oils but little soluble. Forms alcoates: in them it takes the place of water of crystallization as in ($CaCl_2,4C_2H_5HO$). By combustion, into $CO_2 + H_2O$. Proof-spirit contains 49.24 of alcohol by weight. Sp. gr. 0.92 at 15°.5 C. Every additional 0.5 per cent. of absolute alcohol, to alcohol of above strength, is one degree over proof. Spirit under proof, when the gunpowder is left moist, after the burning off of the spirit. H_2O removed by digestion with CaO for two or three days, and distillation by heat of a calcium chloride bath. By oxydation: $C_2H_5HO + O_2 = HC_2H_3O_2 + H_2O$. By KHO + heat, thus: $C_2H_5HO + KHO = KC_2H_3O_2 + 2H_2$. (ALLYLIC ALCOHOL $\mathbf{C_3H_5HO}$; mobile liquid; boils at 103° C. Oxydized into: ACROLEINE C_3H_3HO and ACRYLIC ACID HC_3H_3OO. ALLYLIC ETHER $\mathbf{C_3H_5,C_3H_5O}$.) 3. PROPYLIC OR TRITYLIC ALCOHOL $\mathbf{C_3H_7HO}$. Colourless liquid of fruity odour; boils at 96° C., and dissolves freely in water. Sp. gr. of liquid 0.817. By distillation of the fermented marc of grapes: affords a mixture of this with 4th, 5th, and 6th of the series. By oxydation: $C_3H_7HO + O_2 =$ PROPIONIC ACID $\mathbf{HC_3H_5O_2} + H_2O$. 4. BUTYLIC OR TETRYLIC ALCOHOL $\mathbf{C_4H_9HO}$. Colourless liquid. Sp. gr. 0.8032: boils at 109° C. By oxydation: $C_4H_9HO + O_2 =$ BUTYRIC ACID $\mathbf{HC_4H_7O_2} + H_2O$. 5. AMYLIC ALCOHOL OR PENTYLIC ALCOHOL $\mathbf{C_5H_{11}HO}$. Also called fousel-oil and potato-spirit. Colourless, limpid liquid, of vinous, oppressive odour (choky). Sp. gr. at 0° C. is 0.827. Boils at 132° C. Little soluble in H_2O: a frequent impurity in crude brandies, accumulating in last distillate. Heated with KHO into $2H_2 +$ POTASSIUM VALERIANATE $KC_5H_9O_2$. By oxydation: $C_5H_{12}O + O_2 =$ VALERIC ACID $\mathbf{HC_5H_9O_2} + H_2O$. 6. CAPROIC OR HEXYLIC ALCOHOL $\mathbf{C_6H_{13}HO}$. Limpid liquid of aromatic odour, insoluble. Sp. gr. at 0° C., 0.833. Boils at about 149° C. By oxydation: $C_6H_{13}HO + O_2 =$ CAPROIC ACID $\mathbf{HC_6H_{11}O_2} + H_2O$. 7. OENANTHYLIC ALCOHOL $\mathbf{C_7H_{15}HO}$. Transparent liquid of

powerful odour. Sp. gr. 0.819. Boils at 177° C. 8. CAPRYLIC or OCTYLIC ALCOHOL $C_8H_{17}HO$. Aromatic liquid, insoluble; soluble in alcohol, ether, and acetic acid. Sp. gr. 0.823 at 16°C. Boils at 180° C. From ricinoleic acid and caustic potash. Thus: $C_{18}H_{34}O_3 + 2KHO = H_2 + C_8H_{17}HO$ + POTASSIUM SEBATE $K_2C_{10}H_{16}O_4$. 12. LAURIC ALCOHOL $C_{12}H_{25}HO$ from the oil of *Balaena rostrata*. 16. CETYLIC ALCOHOL OR ETHAL $C_{16}H_{33}HO$; a white solid fat, fusible at 48° C.; soluble in hot C_2H_5HO. It is the chief constituent of pure spermaceti or cetin. By oxydation: $C_{16}H_{33}HO + O_2 = H_2O$ + PALMITIC ACID $HC_{16}H_{31}O_2$. 30. MELISSYLIC ALCOHOL $C_{30}H_{61}HO$ (Melissin) contained in myricin (that part of bees'-wax insoluble in C_2H_5HO) as palmitate of the oxide of melissyl. By saponification with potash, this alcohol obtained. A solid of silken lustre; fuses at 85° C. Very soluble in benzol. By oxydation into H_2O + MELISSIC ACID and $HC_{30}H_{59}O_2$. **Vinous fermentation.** A change through the aid of a ferment, in which organic bodies of the amylaceous and saccharine type, break up into other compounds of less complex structure. The ferment always a nitrogenized body in a state of change. In grape-juice, the albumen by oxydation becomes the ferment. YEAST, a great ferment: consists of small, oval, organized cells, nucleated, not above $\frac{1}{250}$ of an inch, or $\frac{1}{\text{mm.}}$ in diameter. In dry yeast 10 per cent. of N and 7.5 per cent. of phosphates. DIASTASE is the ferment of germinating seeds and buds: malt contains $\frac{1}{300}$ of it. One part changes 2000 parts of starch into dextrin and glucose. SYNAPTASE or EMULSIN, the ferment derived from bitter almonds. It resembles diastase, and is coagulated by boiling water. It changes AMYGDALIN $C_{20}H_{27}NO_{11}$ into HYDRIDE OF BENZOYL $C_7H_5O.H$, FORMIC ACID $HCHO_2$, GLUCOSE $C_6H_{12}O_6$, HYDROCYANIC ACID HCN, and H_2O. When glucose ferments, it breaks up into: $2C_2H_6O + 2CO_2 + H_2O$. Temperature of 21°.2 C. most favourable to vinous fermentation. Port contains from 15 to 17 per cent. of C_2H_6O, Sherry 14 to 16, Madeira 14 to 17, Amontillado 12.6, Claret 8 to 9, Rhine wines from 7 to 10 per cent. of alcohol, calculated as absolute. Claret, Burgundy, and Rhine-wines contain but little sugar; sherry less than port. CREAM OF TARTAR $KHC_4H_4O_6$, in grape-wines; least in old wines. Alcohol in wine rouses sluggish digestions, limits the metamorphosis of food, gives temporary strength to nervous system, carries off the effect of chills, and prevents the absorption of bad odours. When diet is insufficient, it arrests the progress of decay till nature can again assert the power of the stomach to take food. **Aldehydes** (from *alcohol de-hydrogenatus*) are **hydrides of certain radicals. Produced by imperfect oxydation of alcohols.** They absorb O freely, and are changed into acids, and they form soluble compounds with Sodium hydrogen sulphite. 1. FORMIC ALDEHYDE CH_2O. 2. ACETIC

ALDEHYDE C_2H_4O or C_2H_3HO. Volatile, pungent liquid of sp. gr. 0.800: boils at 20° C. Unites with NH_3 to ALDEHYDE AMMONIA $C_2H_3(NH_4)O$, a white substance, soluble in H_2O, insoluble in $C_4H_{10}O$, fusing below 100° C., and sublimes. Aldehyde reduces Ag salts. By Cl into: CHLORAL C_2HCl_3O. Thus: $C_2H_4O + 3Cl_2 = C_2HCl_3O + 3HCl$. Heated with KHO: $C_2H_4O + KHO = KC_2H_3O_2 + H_2$. Polymeric: met-aldehyde, el-aldehyde, and par-aldehyde. Made: 1. By passing C_2H_4HO through a red-hot tube. 2. By $K_2Cr_2O_7 + H_2SO_4 + C_2H_5HO$. 3. By distilling and rectifying 6 parts MnO_2, 6 of H_2SO_4, 4 of H_2O, and 4 of C_2H_5HO. Then from $C_2H_3(NH_4)O$ by H_2SO_4. (ACETAL $C_6H_{14}O_2 = (C_2H_5)_2O,C_2H_4O$. Colourless liquid, ethereal, of sp. gr. 0.821. Boils at 105° C. By further oxydation, into acetic aldehyde and acetic acid.) 3. PROPIONIC ALDEHYDE C_3H_6O or C_3H_5HO. Limpid, ethereal liquid; sp. gr. 0.79. Boils above 55° C. 4. BUTYLIC ALDEHYDE C_4H_8O or C_4H_7HO. Ethereal, pungent liquid, sparingly soluble in H_2O. Sp. gr. 0.8. Boils about 70° C. Butyral is isomeric. 5. VALERIC ALDEHYDE $C_5H_{10}O$, or C_5H_9HO. Limpid, pungent fluid, insoluble. Sp. gr. 0.82; boils at 96° C. 6. CAPROIC ALDEHYDE $C_6H_{12}O$. OENANTHYLIC ALDEHYDE $C_7H_{14}O$ or $C_7H_{13}HO$. Also called Oenanthol. Oil-like compound, from destructive distillation of castor-oil. Sp. gr. 0.827. Boils at 156° C. 8. CAPRYLIC ALDEHYDE $C_8H_{16}O$. Insoluble. Sp. gr. 0.818. Boils at 171° C. 9. PELARGONIC ALDEHYDE $C_9H_{18}O$. 10. RUTIC ALDEHYDE $C_{10}H_{20}O$. 11. EUODIC $C_{11}H_{22}O$. Boils at 213° C. Sp. gr. 0.85. Chief constituent of oil of rue. 12. LAURIC ALDEHYDE $C_{12}H_{24}O$.

Ketones or acetones. Related to aldehydes. By distilling the calcium salt of any of the monobasic volatile acids. Thus: $Ca2C_2H_3O_2 = CaCO_3 +$ ACETONE C_3H_6O. Colourless, ethereal liquid, of sp. gr. 0.792. Boils at 56° C. Considered as ACETYL METHYLIDE C_2H_3O,CH_3. PROPIONE $C_5H_{10}O$. BUTYRONE $C_7H_{14}O$. VALERONE $C_9H_{18}O$.

The vinic acids. 1. METHYLSULPHURIC ACID HCH_3SO_4, in crystals. 2. ETHYL-SULPHURIC ACID $HC_2H_5SO_4$; unstable syrup. Also called sulpho-vinic acid. $Ca2C_2H_5SO_4,2H_2O$. Six-sided tables. Isomeric acids: ISETHIONIC, PARETHIONIC, and ALTHIONIC ACIDS. ETHYL-CARBONIC ACID $HC_2H_5CO_3$. Not isolated. ETHYL-OXALIC ACID $HC_2H_5C_2O_4$. ETHYL-PHOSPHORIC ACID $H_2C_2H_5PO_4$, &c., &c.

Ethers: simple, double, and compound. 1. METHYLIC ETHER CH_3,CH_3O. A gas of sp. gr. 1.617. 2. ETHYLIC ETHER C_2H_5, C_2H_5O or $C_4H_{10}O$. Transparent, colourless liquid, of high refracting power; of ethereal odour and burning taste. Very volatile and inflammable. Sp. gr. at 0° C. 0.7365. Boils at 35° C. Relative weight 37. H_2O dissolves $\frac{1}{8}$ of its bulk. Solvent of fats and oils, of salts as $HgCl_2$, $AuCl_3$, $PtCl_4$; to slight extent

of P and S. Most favourable point of etherification between 140° to 143°C. Formation of SULPHETHYLIC ACID $=\mathbf{HC_2H_5SO_4}$. $C_2H_5HO + H_2SO_4 = H_2O + HC_2H_5SO_4$. The effects of heat upon $HC_2H_5SO_4$ may be thus represented:

Below 127°C.	$HC_2H_5SO_4 + H_2O$	$= H_2SO_4 + C_2H_5HO$.
At 149°C.	$2(HC_2H_5SO_4) + H_2O$	$= H_2SO_4 + C_4H_{10}O$.
„ 160°C.	$HC_2H_5SO_4$	$= H_2SO_4 + C_2H_4$.

[ALLYLIC ETHER $\mathbf{C_3H_5,C_3H_5O}$. *Prep.* $C_3H_5I + KC_3H_5O = KI + (C_3H_5)_2O$. In oil of garlic together with ALLYL SULPHIDE $\mathbf{C_3H_5,C_3H_5S}$.] 3. PROPYLIC ETHER $\mathbf{C_3H_7,C_3H_7O}$. 4. BUTYLIC ETHER $\mathbf{C_4H_9,C_4H_9O}$. Both but little known. 5. AMYLIC ETHER $\mathbf{C_5H_{11},C_5H_{11}O}$; boils at 176°.5. **Double ethers.** The higher ones but little known. METHYL-ETHYLIC ETHER $\mathbf{CH_3,C_2H_5,O}$. Thus: $C_2H_5I + C_2H_3KO = KI + CH_3,C_2H_5O$. Or: $CH_3I + C_2H_5KO = KI + CH_3,C_2H_5,O$. Boils at 11°C. METHYL-AMYLIC ETHER $\mathbf{CH_3,C_5H_{11},O}$; boils at 92°C. ETHYL-CAPRYLIC ETHER $\mathbf{C_2H_5,C_8H_{17},O}$. AMYL-ETHYLIC ETHER $\mathbf{C_5H_{11},C_2H_5O}$; boils at 112°C.

Alcohol radicals with metallic derivatives. POTASSIUM METHYLATE $\mathbf{KCH_3O}$. POTASSIUM ETHYLATE $\mathbf{KC_2H_5O}$. [POTASSIUM ALLYLATE $\mathbf{KC_3H_5O}$.] POTASSIUM AMYLATE $\mathbf{KC_5H_{11}O}$. With **Zn.** ZINC METHYLE $\mathbf{(CH_3)_2Zn}$. Spontaneously inflammable liquid, heavier than water. ZINC ETHYLE $\mathbf{(C_2H_5)_2Zn}$. Colourless, mobile liquid of sp. gr. 1.182. Boils at 118°C. By slow oxydation into ZINC-ALCOHOL $\mathbf{(C_2H_5)_2ZnO_2}$. By NH_3, into zinc amide and ethylic hydride: $(C_2H_5)_2Zn + 2NH_3 = (NH_2)_2Zn + 2C_2H_5H$. By heating zinc ethyl with ethyl-iodide we obtain ETHYL $\mathbf{C_2H_5,C_2H_5}$. (FRANKLAND.) Thus: $(C_2H_5)_2Zn + 2C_2H_5I = ZnI_2 + 2(C_2H_5,C_2H_5)$. By the action of CO_2 upon potassium ethyl, Wanklyn obtained potassium propionate $C_3H_5KO_2$. Zinc ethyl most useful in obtaining other ethyles, as silicic, mercuric, plumbic, &c., by action upon silicic, mercuric, and plumbic chlorides. ZINC AMYLIDE $\mathbf{(C_5H_{11})_2Zn}$: colourless, fuming liquid. With **Hg.** MERCURIC METHYL $\mathbf{(CH_3)_2Hg}$. Sp. gr. of liquid 3.07; boils at 96°C. MERCURIC ETHYL $\mathbf{(C_2H_5)_2Hg}$. A liquid of sp. gr. 2.46. Boils at 159°C. MERCURIC METHYL-IODIDE $\mathbf{CH_3HgI}$, in scales. Thus: $(CH_3)_2Hg + HgI_2 = 2CH_3HgI$. With **P.** PHOSPH-ETHYL $\mathbf{(C_2H_5)_3P}$. Insoluble in water; boils at 127°C. Spontaneously inflammable. Unites with C_2H_5I to: iodide of tetrethyl phosphonium $(C_2H_5)_4PI$. $\mathbf{(C_2H_5)_3P}$ is obtained by the action of PCl_3 upon $(C_2H_5)_2Zn$. Thus: $3(C_2H_5)_2Zn + 2PCl_3 = 3ZnCl_2 + 2(C_2H_5)_3P$. With **As.** ARSENICUM METHYL $\mathbf{(CH_3)As}$. Colourless liquid; boils at 120°C. By the action of CH_3I upon an alloy of Na with As. ARSENICUM DI-METHYL $\mathbf{((CH_3)_2As)_2}$ or **Kd**, is KAKODYLE. Colourless liquid; boils at 170°C. Spontaneously inflammable in air. Of disgusting garlic odour. Very

poisonous. [KAKODYLIC OXIDE ($(CH_3)_2As)_2O$ or Kd_2O, is Alkarsin. Colourless, ethereal fluid, of offensive odour; very little soluble in water. Formed by distilling As_2O_3 with $4KC_2H_3O_2 = 2K_2CO_3 + 2CO_2 + ((CH_3)_2As)_2O$. KAKODYLIC ACID $H(CH_3)_2AsO_2$ or $HKdO_2$. Colourless crystals; deliquescent. Not poisonous.] With **Sb**. STIB-ETHYL $(C_2H_5)_3Sb$. Heavy liquid of garlic odour. Obtained by the action of sodium stibide on ethyl-iodide or of $SbCl_3$ upon $(C_2H_5)_2Zn$. Boils at 158°.5C., and inflames in air. With **Bi**. BISMUTH-ETHYL $(C_2H_5)_3Bi$. Colourless liquid, spontaneously inflammable. With **B**. BOR-ETHYL $(C_2H_5)_3B$.

Compound ethers. Chlorides of alcohol radicals are formed, together with water, when HCl is made to react upon the alcohols. Thus: $HCl + CH_3HO = H_2O + CH_3Cl$. Also by the action of PCl_5 upon $CH_3HO = HCl + POCl_3 + CH_3Cl$. METHYL CHLORIDE CH_3Cl: colourless liquid of sp. gr. 1.731. Thus: $NaC_2H_3O_2 + 2ICl = NaCl + CO_2 + I_2 + CH_3Cl$. ETHYL CHLORIDE OR HYDROCHLORIC ETHER C_2H_5Cl boils at 11°C. By red heat into $C_2H_4 + HCl$. ETHYL IODIDE C_2H_5I: colourless liquid; boils at 70°.3C. SULPHIDE $(C_2H_5)_2S$: colourless liquid of garlic odour; boils at 73°C. MERCAPTAN OR ETHYL HYDROGEN SULPHIDE C_2H_5HS: inflammable liquid of intense garlic odour; boils at 36°C. Sp. gr. 0.835. Salts called MERCAPTIDES as $K(C_2H_5)S$. *Prep.* By distilling potassium ethyl sulphate with KHS. Thus: $KC_2H_5SO_4 + KHS = K_2SO_4 + C_2H_5,HS$. CYANIDE C_2H_5Cy: poisonous liquid, of sp. gr. 0.787. Boils at 88°C. METHYL ACETATE $CH_3,C_2H_3O_2$: a product of destructive distillation of wood. Sp. gr. 0.956. Boils at 56°.3C. METHYL SALICYLATE $CH_3,C_7H_5O_3$: essential oil of Winter-green *Gaultheria procumbens*, and of *Betula lenta*. METHYL OXALATE $(CH_3)_2C_2O_4$. Transparent crystalline plates. ETHYL ACETATE $C_2H_5,C_2H_3O_2$ or ACETIC ETHER: colourless liquid of pleasant odour. Sp. gr. 0.89. Boils at 74°C. ETHYL FORMATE C_2H_5,CHO_2: liquid, of faint odour as of HCy. Sp. gr. 0.915 at 18°C. Boils at 53°C. OENANTHIC ETHER probably a mixture of $C_2H_5,C_8H_{15}O_2$ and $C_2H_5,C_{10}H_{19}O_2$; gives fragrance to wines. Sp. gr. 0.872. Boils at about 230°C. ETHYL OXALATE $(C_2H_5)_2C_2O_4$: colourless, ethereal liquid. Boils at 184°C. Sp. gr. 1.093. By alcoholic solution of NH_3 into: OXAMIDE $C_2N_2H_4O_2$, a greyish-white solid. Thus: $(C_2H_5)_2C_2O_4 + 2NH_3 = 2C_2H_5HO + C_2N_2H_4O_2$. OXAMIDE is ammonium oxalate minus $2H_2O$. ETHYL CYANATE C_2H_5,CNO: pungent, volatile. Sp. gr. 0.898. By KHO into ETHYLIA or ETHYLAMINE C_2H_5,NH_2. Thus: $C_2H_5CNO + 2KHO = K_2CO_3 + C_2H_5NH_2$. ETHYLIA is a powerful base. ETHYL CARBONATE $(C_2H_5)_2CO_3$: a liquid of aromatic odour; boils at 125°C. Sp. gr. 0.975. Obtained by heating Ag_2CO_3 with $2(C_2H_5I)$. Heated with alcoholic solution of NH_3 into URETHANE or CARBAMIC ETHER C_2H_5,NH_2CO_2. Resembles spermaceti. By NH_3, urethane

changes into alcohol and urea. ETHYL SULPHATE $(C_2H_5)_2SO_4$. An oily liquid of sp. gr. 1.120. *The true sulphuric ether.* By heat into SO_2,C_2H_5HO and C_2H_4. ETHYL NITRATE C_2H_5,NO_3. Sp. gr. of liquid 1.112; boils at 85°C. ETHYL NITRITE C_2H_5,NO_2: pale yellow, with odour of apples. Sp. gr. 0.947; boils at 16°.6C. A solution in alcohol mixed with aldehyde, constitutes *Spiritus etheris nitrosi.* AMYL ACETATE $C_2H_3,C_2H_3O_2$: a fragrant liquid, with odour of Jargonelle pears. Boils at 137°C.

Action of halogens upon ethers and alcohols. DICHLORINATED ETHER $(C_2H_3Cl_2)_2O$: oily liquid of sp. gr. 1.501. PERCHLORINATED ETHER $(C_2Cl_5)_2O$: solid. CHLORAL or TRICHLOR-ALDEHYDE C_2HCl_3O: oily liquid: by a little H_2O into a solid hydrate. Sp. gr. 1.502; boils at 94°C. Made by passing Cl_2 into alcohol to complete saturation. By KHO into potassium formate and Chloroform. Thus: $C_2HCl_3O + KHO = KCHO_2 + CHCl_3$. By HNO_3 into: CHLORACETIC ACID $HC_2Cl_3O_2$. BROMAL C_2HBr_3O: colourless, oily liquid, of sp. gr. 1.497; boils at 100°.5C. CHLOROFORM $CHCl_3$: volatile, ethereal liquid. Sp. gr. 1.497; boils at 61°C. Very little soluble in H_2O; solvent of fats, resins, alkaloids, &c. IODOFORM CHI_3, yellow solid. BROMOFORM $CHBr_3$.

Hydrocarbon radicals from monatomic alcohols. They belong to the type H}H. The reaction between certain metals and ethyl iodide may be thus represented, as it is proved that the formation of C_2H_5 is preceded by a compound of metal with ethyl. 1. $2(C_2H_5I)+Zn\}Zn=ZnI_2+(C_2H_5)_2Zn$. 2. $(C_2H_5)_2Zn + 2(C_2H_5I) = ZnI_2 + 2(C_2H_5\}C_2H_5)$. METHYL $CH_3\}CH_3$: a gas of sp. gr. 1.0365; burns with blue flame. ETHYL $C_2H_5\}C_2H_5$: gas, of sp. gr. 2.046. TETRYL, BUTYL, or VALYL $C_4H_9\}C_4H_9$: boils at 106°C. Sp. gr. 0.7057. ETHYL-BUTYL $C_2H_5\}C_4H_9$: boils at 62°C. AMYL $C_5H_{11}\}C_5H_{11}$: boils at 155°C. ETHYL-AMYL $C_2H_5\}C_5H_{11}$: boils at 88°C. CAPROYL $C_6H_{13}\}C_6H_{13}$: boils at 202°C. METHYL-CAPROYL $CH_3\}C_6H_{13}$: boils at 82°C. BUTYL-AMYL $C_4H_7\}C_5H_{11}$: boils at 132°C. BUTYL-CAPROYL $C_4H_7\}C_5H_{11}$: boils at 155° C. In complete correspondence are the **hydrides** of these **radicals.** METHYL HYDRIDE $CH_3\}H$.

The diatomic alcohols: glycols. Compounds formed on the type of two molecules of water. Prepared from hydrocarbons, homologous with ethylene. Chief radical: ETHYLENE C_2H_4. Colourless, inodorous gas, of sp. gr. 14. One vol. of H_2O dissolves 0.256 of the gas. Burns with bright flame, consuming 3 vols. of O to each vol. of the gas. Absorbed by H_2SO_4,SO_3. May be compressed into a liquid. *Prep.* $HC_2H_5SO_4$ by heat $= H_2SO_4 + C_2H_4$. In combination, one atom of C_2H_4, can replace 2 atoms of H. PROPYLENE C_3H_6: a gas of sp. gr. 1.498. BUTYLENE C_4H_8. AMYLENE C_5H_{10}: colourless liquid; boils at 39°C. Anæsthetic. 1. ETHYLENE ALCOHOL or GLYCOL $C_2H_6O_2$ or C_2H_4,H_2O_2: a liquid of sweet taste. Sp. gr. 1.125; boils at

197°.5C. From ETHYLENE ACETATE $C_2H_4 2C_2H_2O_2$, by digestion upon BaH_2O_2. By oxydation into GLYCOLIC ACID HC_2H_3O,O_2. Thus: $C_2H_6O_2 + O_2 = H_2O + HC_2H_3O,O_2$. Further oxydized into oxalic acid. GLYCOL ETHER, or ETHYLENE OXIDE C_2H_4O: volatile liquid; boils at 13°.3C. Prepared by the action of KHO upon ETHYLENIC HYDROCHLORIDE $C_2H_4,HClO$. ETHYLENE MERCAPTAN C_2H_4HS: oily liquid; boils at 148°C. GLYCOL CHLORIDE $(C_2H_4)Cl_2$ is "Dutch liquid." 2. PROPYLENE ALCOHOL $C_3H_8H_2O_2$: boils at 188°C. By slow oxydation into lactic acid. PROPYLENE ETHER C_3H_6O. 3. AMYLENE ALCOHOL $C_5H_{10}H_2O_2$, &c.

Triatomic alcohols. GLYCERIN C_3H_5,H_3O_3: the basis of fats. *See* the fats, p. 90. Contains the triad radical GLYCERYL C_3H_5. Colourless syrup, of sp. gr. 1.28; very soluble in water and in alcohol. Slightly volatile at 100°C. Only distillable in superheated steam. Obtained from palm-oil and other fats, by distillation in super-heated steam. Thus PALMITINE $C_3H_5,(C_{16}H_{31}O_3)O_3 + 3H_2O = 3HC_{16}H_{31}O_2 +$ GLYCERIN $C_3H_5H_3O_3$. By heat, glycerin changes into $2H_2O$ and ACROLEIN C_3H_4O, a fluid of burning taste and irritating odour. Best obtained by distilling glycerin with $KHSO_4$. HCl decomposes glycerin into: 1. MONOCHLORHYDRIN $C_3H_7O_2Cl + H_2O$. 2. DICHLORHYDRIN $C_3H_6OCl_2 + H_2O$. 3. EPICHLORHYDRIN $C_3H_5OCl + HCl$.

Fatty acids, the derivatives of the alcohols by full oxydation. 1. FORMIC ACID $HCHO_2$: native in *Formica rufa* and in *Urtica urens*. Fuming, irritating liquid. Boils at 105°C. Below 0°C. in scales. Reducing agent. *Formates.* By H_2SO_4 into $H_2O + CO$. By BaH_2O_2 a formate is changed into an oxalate and H_2. Thus: $2(HCHO_2) = H_2C_2O_4 + H_2$. *Prep.* $H_2C_2O_4 = CO_2 + HCHO_2$. ANHYDRIDE CHO,CHO,O. 2. ACETIC ACID $HC_2H_3O_2$; "glacial" in shiny, colourless plates, fusing at 17°C.; sp. gr. of liquid 1.063. Sharp taste, blisters the tongue; boils at 117°C., and distils. Radical OTHYL C_2H_3O. *Prep.* From $NaC_2H_3O_2 + H_2SO_4$ by distillation. Also from ethylic alcohol by oxydation. Thus: $C_2H_5HO + O_2 = H_2O + HC_2H_3O_2$. ANHYDRIDE C_2H_3O,C_2H_3O,O or $C_4H_6O_3$; boils at 137°.5C. ACETATES. $KC_2H_3O_2$: used in medicine as a diuretic. Foliated, deliquescent. $NH_4C_2H_3O_2$ in solution, is Spiritus Mindererus of medicine; diaphoretic. $Fe_2 3C_2H_3O_2$ deep-red; a test. $Pb2C_2H_3O_2,3H_2O$ in right rhombic prisms, or in masses of white crystals of sweet taste. *Sugar of lead.* Soluble in less than two of H_2O. By heat anhydrous, then fuses; if temperature is raised, into: ACETONE C_3H_6O, CO_2 and PbH_2O_2, $2(Pb2C_2H_3O_2)$, in pearly scales, alkaline, freely soluble. $Pb2C_2H_3O_2,2PbO,H_2O$, is Goulard's extract; in crystals, by NH_3 to a solution of acetate. Formed in manufacture of white lead $PbH_2O_2,2PbCO_3$. $CuO_2Cu2C_2H_3O_2,6H_2O$ is verdigris. Schweinfurth green is $Cu2C_2H_3O_2,2(Cu2AsO_2)$. $AgC_2H_3O_2$ in silken needles,

little soluble. $HgC_2H_3O_2$, in brilliant scales, little soluble. [ACETAL $C_6H_{14}O_2 = (C_2H_5)_2O,C_2H_4O$: colourless, ethereal liquid, of sp. gr. 0.821; boils at 105°C. A product of slow oxydation of vinic alcohol. CHLOR-ACETIC ACID $HC_2H_2ClO_2$ melts at 63°C. TRI-CHLORACETIC ACID $HC_2Cl_3O_2$ melts at 46°C. Also compounds with Br and I. THI-ACETIC ACID HC_2H_3OS; a colourless liquid; boils at 93°C. SULPH-ACETIC ACID $HC_2H_3OSO_4$. ACETONE C_3H_6O: ethereal liquid of sp. gr. 0.792. Boils at 56°C. *Prep.* By distilling Calcium acetate with CaO. $Ca2C_2H_3O_2 = CaCO_3 + C_3H_6O$. Also by passing vapours of acetic acid through a red-hot tube: $2HC_2H_3O_2 = CO_2 + H_2O + C_3H_6O$. The ketone of acetic acid. PROPIONE $C_5H_{10}O$: oily liquid. ACETYLENE C_2H_2, or KLUMENE; gas of disagreeable odour, very soluble. It burns with smoky flame. With nascent hydrogen forms Ethylene C_2H_4. From ether at red heat.] 3. PROPIONIC ACID $HC_3H_5O_2$; in crystalline plates, soluble in H_2O; very fusible. Boils at 140°C. So called because the first of the fatty acids. Produced in the fermentation of glycerin, by the oxydation of PROPIONE $C_5H_{10}O$, of oleic acid, and also from ethyl cyanide C_2H_5Cy by KHO and $H_2O = NH_3$ and potassium propionate. Thus: $C_2H_5,CN + H_2O + KHO = KC_3H_5O_2 + NH_3$. 4. BUTYRIC ACID $HC_4H_7O_2$, of sp. gr. 0.9886 at 0°C. Boils at 157°C. Liquid with odour of rancid butter. By fermenting sugar with casein at 35°C. Thus: $C_{12}H_{22}O_{11} + 2H_2O = 4CO_2 + 4H_2 + H_2O + 2HC_4H_7O_2$. 5. VALERIC ACID $HC_5H_9O_2$: oily liquid, boiling at 175°C. Soluble in alcohol and ether. Found in *Valerian*, and berries of *Viburnum opulus*, and in decaying cheese. Prepared by oxydation of valeric alcohol. 6. CAPROIC ACID $HC_6H_{11}O_2$: a liquid with odour of perspiration; boils at 200°C. 7. OENANTHYLIC ACID $HC_7H_{13}O_2$: boils at 148°C. By oxydation of castor-oil. 8. CAPRYLIC ACID $HC_8H_{15}O_2$: melts at 15°C. 9. PELARGONIC ACID $HC_9H_{17}O_2$: oily fluid, insoluble in H_2O. 10. CAPRIC OR RUTIC ACID $HC_{10}H_{19}O_2$. In needles which fuse at 30°C.; smells of goats. "Oil of rue" is $C_{10}H_{20}O$. 12. LAURIC ACID $HC_{12}H_{23}O_2$: fuses at 43°.5C. In berries of *Laurus nobilis*, in cocoa-nut oil, &c. 14. MYRISTIC ACID $HC_{14}H_{27}O_2$: melts at 54°C. In nutmeg-butter. 16. PALMITIC ACID $HC_{16}H_{31}O_2$: white fat, fusing at 62°C. 17. MARGARIC ACID $HC_{17}H_{33}O_2$: fuses at 60°C. 18. STEARIC ACID $HC_{18}H_{35}O_2$: pearly scales, fusing at 70°.5C. Solution in hot alcohol, reddens litmus. Pure in the oil of *Bassia latifolia*.

Fatty acids *continued*: **of the oleic acid type.** Heated with KHO they break up into acetic, and another acid of the stearic group, with liberation of hydrogen. [2. ACRYLIC ACID $HC_3H_3O_2$: liquid of acid, burning taste; boils above 100°C. *Acrylates* all soluble. *Prep.* From ACROLEIN C_3H_4O by oxydation $2C_3H_4O + 3Ag_2O = H_2O + 2Ag_2 + 2AgC_3H_3O_2$. 4. ANGELIC ACID $HC_5H_7O_2$:

colourless prisms, fusing at 45°C. 14. MORINGIC ACID $HC_{15}H_{27}O_2$ in *Moringa aptera* (oil of ben). 15. PHYSETOLEIC ACID $HC_{16}H_{29}O_2$: melts at 0°C.; in oil of *Physeter macrocephalus.*] 17. OLEIC ACID $HC_{18}H_{33}O_2$: melts at 14°C. Colourless oil. Potassium oleate in Naples soap; sodium oleate in Marseilles soap. By exposure to NO_2, oleic acid into elaidic acid, which is isomeric; melts at 45°C. [18. DOEGLIC ACID $HC_{19}H_{35}O_2$: in oil from *Balaena rostrata.* 21. ERUCIC ACID $HC_{22}H_{41}O_2$: in oils of colza and mustard.]

Acids of the oxalic acid type: di-basic. Stand to the di-atomic alcohols in the same relation as acetic acid to the monatomic alcohols. 1. OXALIC ACID $H_2C_2O_4.2H_2O$: 4-sided prisms (p. 78). 2. MALONIC ACID $H_2C_3H_2O_4$: in rhomboids. 3. SUCCINIC ACID $H_2C_4H_4O_4$: in rhombic tables, soluble in 5 of cold and 2 of boiling H_2O. In amber (*Succinum*). Easily from calcium malate. Thus: $6CaC_4H_4O_5 = Ca2C_2H_2O_2 + CaCO_3 + H_2O + 3CO_2 + 4CaC_4H_4O_4$. Also from BUTYRIC ACID $HC_4H_7O_2$ by HNO_3. Thus: $2HC_4H_7O_2 + 3O_2 = 2H_2O + 2H_2C_4H_4O_4$. 4. LIPIC ACID $H_2C_5H_6O_4$. 5. ADIPIC ACID $H_2C_6H_8O_4$. 6. PIMELIC ACID $H_2C_7H_{10}O_4$. 7. SUBERIC ACID $H_2C_8H_{12}O_4$: white, crystalline powder. From bark of *Quercus.* 8. ANCHOIC ACID $H_2C_9H_{14}O_4$: fuses at 115°C.] 9. SEBACIC ACID $H_2C_{10}H_{16}O_4$: in pearly scales from H_2O; melts at 127°C. By distilling fixed oils. Also by heating RICINOLEIC ACID $HC_{18}H_{33}O_3$, with KHO. Thus: $HC_{18}H_{33}O_3 + 2KHO = C_8H_{17}HO$ (octylic alcohol) $+ H_2 + K_2C_{10}H_{16}O_4$ (potassium sebate).

Acids of the lactic acid series. 1. GLYCOLIC ACID $HC_2H_3O_3$: uncrystallizable syrup; precipitates lead acetate. 2. LACTIC ACID $HC_3H_5O_3$: syrupy liquid; in gastric juice and fluids of muscular tissue: PARA-LACTIC ACID $HC_3H_5O_3$. $Zn2C_3H_5O_3.3H_2O$ in brilliant 4-sided prisms, soluble in 54 of H_2O. $CaH_24C_3H_5O_3$, H_2O in radiated needles. A product of decomposition of the acid at 260°C. is LACTIC ANHYDRIDE $C_3H_4O_2$. Digested with HI, thus: $HC_3H_5O_3 + 2HI = I_2 + H_2O +$ PROPIONIC ACID $HC_3H_5O_2$. [LACTAMIDE $NH_2,C_3H_5O_2$.]

Fats and oils: general characteristics. Lighter than H_2O, the fixed fats and oils leave a stain upon paper, and cannot be distilled without decomposition. Insoluble in H_2O, little in alcohol, very soluble in ether and benzol. Possess attraction for oxygen; *drying* (walnut, poppy, linseed, hemp) and *non-drying.* The non-drying oils, like castor-oil, olive- and almond-oils, form ELAIDIN with NO_2. Natural separation of fats by cold and pressure. The **common fats** consist chiefly of **olein, margarin, stearin,** and **palmitin**; they saponify with various oxides, giving up their constituent glyceryl in combination with H_2O. Amongst the important fats are: OLIVE-OIL and ALMOND-OIL of sp. gr. 0.918. COLZA-OIL from *Brassica oleifera.* LINSEED-OIL from

Linum usitatissimum. SPERM-OIL from *Physeter macrocephalus*. CASTOR OIL from *Ricinus communis*, is soluble in C_2H_5HO. Affords RICINOLEIC ACID $HC_{18}H_{33}O_3$, by saponification. COCOA-NUT OIL from *Cocos nucifera* is solid below 20°C. Saponified, yields 8 acids. PALM-OIL from *Elais guineensis*; PALMITIN its chief component. BUTTER consists of OLEIN, PALMITIN, with small quantities of BUTYRIN, CAPROIN, and CAPRYLIN. SUET, chiefly of STEARIN: in LARD, olein predominates over margarin and stearin. SPERMACETI consists chiefly of CETIN $C_{32}H_{64}O_2$, the basis of which is ETHAL $C_{16}H_{34}O$. By distillation: CETENE $C_{16}H_{32}$, and PALMITIC ACID. BEESWAX fuses at 63°C. $\frac{3}{8}$ its weight of MYRICIN or PALMITATE OF MELISSYL $C_{30}H_{61},C_{16}H_{31}O_2$ insoluble in C_2H_5HO. $\frac{1}{8}$ of wax consists of CEROTIC ACID $HC_{27}H_{53}O_2$, soluble in boiling C_2H_5HO. CEROLEIN, about 4 to 5 per cent., remains in solution in alcohol.

The chief components of fats and oils. 1. OLEIN or TER-OLEATE OF GLYCERYL $C_{57}H_{104}O_6$ or $C_3H_5(C_{18}H_{32}O_2)_3O_3$: a colourless liquid, the chief constituent of oils. By NO_2 into elaidin, an isomeric solid fat. By destructive distillation into SEBACIC ACID $H_2C_{10}H_{16}O_4$. *Prep.* By dissolving olive-oil in boiling C_2H_5HO; on cooling nearly all the margarin separates. 2. MARGARIN or TRI-MARGARIN $C_{54}H_{104}O_6$ or $C_3H_5(C_{17}H_{33}O)_3O_3$. Nearly insoluble in C_2H_5HO: from ether in shiny scales, fusing at 47°C. *Prep.* From olive-oil by pressure at low temperatures, and repeated crystallization. 3. STEARIN or TRI-STEARIN $C_{57}H_{110}O_6 = C_3H_5(C_{18}H_{35}O)_3O_3$. Pearly scales soluble in ether, and in 7 of boiling C_2H_5HO. Fuses at 62°C. Chief constituent of solid fats. *Prep.* Mutton suet, treated with 10 vols. of ether, is deprived, on boiling, of the small quantities of margarin and olein it contains; stearin depositing on cooling. 4. PALMITIN $C_{51}H_{98}O_6$ or TRI-PALMITIN $C_3H_5(C_{16}H_{31}O)_3O_3$, nearly pure in Japan wax; largely in palm-oil. Melts at three different points; 46°C. and 62°.8C. are the highest and the lowest. Crystallized from ether. SAPONIFICATION. The base of hard soaps, SODA; of soft, POTASH. Soaps of the alkaline-earths, &c., insoluble, hence the curdling of soaps by hard waters. In saponification by CaH_2O_2, the insoluble stearates, &c., are separated from the soluble glycerin, and decomposed by dilute H_2SO_4. The separation of the fatty acids from the glycerin also accomplished by super-heated steam between 260°C. and 316°C.; both the glycerin and the acids distil. GLYCERIN $C_3H_5H_3O_3$: colourless syrup, already described. By dropping glycerin into HNO_3: NITRO-GLYCERIN or GLONOIN $C_3H_5(NO_2)_3O_3$. It explodes violently when heated, and is employed for blasting. Very dangerous. Like a true triatomic alcohol, glycerin forms a SULPHO-GLYCERIC ACID $C_3H_5HSO_3O_3$. PHOSPHO-GLYCERIC ACID, in the brain, and yolk of eggs. [CHLORHYDRIN $C_3H_7ClO_2$; oily ethereal liquid, boils at 227°C.

IODHYDRIN $C_6H_{11}IO_3$; golden-yellow syrup. By dilute solution of KHO into GLYCERIN $C_3H_5H_3O_3$, KI, and GLYCERIC ETHER $C_6H_{10}O_3$. Thus: $2C_6H_{11}IO_3 + 2KHO + H_2O = 2KI + 2C_3H_5H_3O_3 + C_6H_{10}O_3$.

The Volatile or Essential Oils.

Generally colourless, give odour to flowers, &c. Not soluble in H_2O, easily in alcohol and ether. Boiling points above 100°C. Communicate a greasy stain to paper, which volatilizes when warmed. Do not saponify: contain a STEAROPTEN in place of margarin; and an ELAEOPTEN in place of olein. Become resinous, and coloured by oxydation. **Oils consisting of C and H alone.** Many of these isomeric. OIL OF TURPENTINE $C_{10}H_{16}$ from *Pinus abies:* that from the Larch is Venice turpentine; from *Pistacia lentiscus* is Chian turpentine. Volatile, balsamic liquid of sp. gr. 0.864: boils at 160°C. Not soluble in H_2O: dissolves resins, oils, S_2 and P_4. Camphine is a species of turpentine. HCl combines with it and forms $C_{10}H_{16}$,HCl. There are several hydrates. Heated with lead oxide, oil of turpentine into: formic and TERETENIC ACID $C_9H_{14}O_5$. Thus: $2C_{10}H_{16} + 7O_2 = 2HCHO_2 + 2C_9H_{14}O_5$. OIL OF BERGAMOTTE $C_{10}H_{16}$, with a solid $C_{15}H_{10}O_3$. OIL OF LEMONS $C_{10}H_{16}$, also isomeric, with a solid $C_{10}H_{10}O_3$. OIL OF CARRAWAY $C_{10}H_{16}$, with another liquid hydro-carbon, CARVOL $C_{10}H_{14}O$. OIL OF CUBEBS $C_{15}H_{24}$, metameric. **Oils containing oxygen.** OIL OF RUE from *Ruta graveolens*, chiefly RUTOL $C_{11}H_{22}O$. CAMPHOR $C_{10}H_{16}O$, from *Laurus camphora*. Sp. gr. 0.996. A white translucent mass, of hot, then cooling taste, soluble in alcohol, ether, and the essential oils. Fuses at 175°C. Boils at 204°C. Distilled with P_2O_5 into CYMOL $C_{10}H_{14} + H_2O$. Oxydized by HNO_3, into CAMPHORIC ACID $H_2C_{10}H_{14}O_4$. Camphor, from the *Dryobalanops camphora* is $C_{10}H_{18}O$: occurs combined with BORNEENE $C_{10}H_{16}$. OIL OF CUMIN contains CYMOL $C_{10}H_{14}$ and CUMINOL $C_{10}H_{14}O,H$. [CUMINIC ACID $HC_{10}H_{11}O_2$, in colourless plates. By treating the hydride, or cuminol, with alcoholic solution of potash we obtain CUMINIC ALCOHOL $C_{10}H_{13}HO$.] OIL OF THYME is a mixture. Contains THYMOL $C_{10}H_{14}O$. OIL OF ANISEED $C_{10}H_{12}O$: in seed of *Pimpinella anisum*. By oxydation with HNO_3, into ANISYL HYDRIDE $C_8H_7O_2,H$. [ANISIC ACID $HC_8H_7O_3$; distilled with $BaO = BaCO_3 +$ ANISOL C_7H_8O.] OIL OF CINNAMON contains CINNAMYL HYDRIDE C_9H_7O,H; boils from 221°C. to 229.5°C. [By oxydation: CINNAMIC ACID $HC_9H_7O_2$. Found in Tolu and Peruvian balsams. Resembles benzoic acid. Distilled with $BaO = BaCO_3 +$ CINNAMOL C_8H_8. CINNAMIC ALCOHOL C_9H_8HO.] OIL OF SPIRAEA or MEADOW-SWEET contains SALICYL HYDRIDE $HC_7H_5O_2$ or SALICYLOUS ACID. Boils at 182°C.

[N.B. SALICIN $C_{13}H_{18}O_7$; white needles of bitter taste, in bark of *Salix*, *Populus*, &c. Heated with $K_2Cr_2O_7$ + dilute H_2SO_4, $2H_2O$ into: OIL OF SPIRAEA, CO_2, and Formic acid. Boiled with HCl into SALIGENIN $C_7H_8O_2$. SALICYLIC ACID $HC_7H_5O_3$; little soluble. METHYL SALICYLATE, $HC_7H_4(CH_3)O_3$, is OIL of *Gaultheria procumbens* or *Winter green*. POPULIN $C_{20}H_{22}O_8$, $2H_2O$; resembles salicin. Contains the elements of salicin benzoate. PHLORIDZIN $C_{21}H_{24}O_{10}.2H_2O$; silken needles, in root-rind of cherry. By acid into glucose, and PHLORETIN $C_{15}H_{14}O_5$. ESCULIN or POLYCHROME $C_{21}H_{24}O_{13}$; colourless needles. In bark of Æsculus. QUERCITRIN $(C_{29}H_{30}O_{17})_2H_2O$, in bark of *Quercus tinctoria*. Yellow crystals. Boiled with dilute $H_2SO_4,2H_2O$ into glucose and QUERCETIN $C_{23}H_{16}O_{10}$. DATISCIN $C_{21}H_{22}O_{12}$, in leaves of *Datisca cannabina*. Colourless crystals. By dilute acids into glucose and DATISCETIN $C_{15}H_{10}O_6$. SAPONIN $C_{12}H_{20}O_7$ (?) in root of *Saponaria*, &c. Colourless mass, soluble in water. COUMARIN $C_9H_6O_2$ in *Tonka-bean*, *Melilotus*, *Asperula*, *Anthoxanthum*, &c. By KHO into COUMARIC ACID $HC_9H_7O_3$. ANTIARIN $C_{14}H_{20}O_5,2H_2O$ in *Upas antiar*. Pearly scales, very poisonous. ELATERIN $C_{20}H_{28}O_5$ in *Momordica elaterium*. White, silken mass. GENTIANIN $C_{14}H_{10}O_5$ in *Gentiana lutea*. Yellow needles; very bitter. PICROTOXIN $C_5H_6O_2$ in *Cocculus indicus*. Colourless, stellate needles. SANTONIN $C_{15}H_{18}O_3$ in *Artemisia santonica*. COLOCYNTHIN $C_{56}H_{84}O_{23}$, in *Cucumis colocynthis*.] **Benzoic series.** ESSENCE OF BITTER ALMONDS, or BENZOYL HYDRIDE C_7H_5O,H; fragrant liquid, not poisonous. Sp. gr. 1.05. Boils at 180°C. Not contained in bitter almonds, but from AMYGDALIN $C_{20}H_{27}NO_{11},3H_2O$ acted upon by SYNAPTASE or EMULSIN, a species of diastase. Thus: $2(C_{20}H_{27}NO_{11}) = 4C_7H_5O,H + 2HCN + C_6H_{12}O_6 + 4HCHO_2 + 4H_2O$. Readily oxydizes to benzoic acid. BENZOIC ACID HC_7H_5OO, or benzoyl oxide. Contained in gum benzoin, *Styrax benzoin*. Light, flexible needles; melts at 120°C., sublimes at 145°C. Soluble in 200 of cold, and 25 of boiling H_2O. BENZOIC ANHYDRIDE $C_7H_5O,C_7H_5O_2$, by decomposing $NaC_7H_5O_2$ with benzoyl chloride. Benzoates mostly soluble. FERRIC BENZOATE insoluble in H_2O, soluble in alcohol. CALCIUM BENZOATE $Ca2C_7H_5O_2$ is now prepared by heating CALCIUM PHTHALATE $CaC_8H_4O_4$ with CaH_2O_2: $CaCO_3$ formed at same time. By HNO_3, benzoic into NITRO-BENZOIC ACID HC_7H_4,NO_2,O_2. By distilling calcium benzoate, it changes into $CaCO_3$, and: BENZONE or BENZOPHENONE C_6H_5,C_7H_5O. An oily fluid, distils. BENZOL or BENZINE C_6H_6, limpid fluid of sp. gr. 0.85 at 15°C. Boils at 80°.6C. [Heated with alcoholic solution of KHO, and distilled, nitro-benzol yields AZO-BENZOL $(C_6H_5N)_2$ in red crystals, and PHENYLAMIN or ANILIN C_6H_7N or C_6H_5,NH_2 p. 101. DINITRO-BENZOL $C_6H_4(NO_2)_2$. CHLORO-BENZOL $C_7H_6Cl_2$, crystalline solid. By distillation with $2AgC_2H_3O_2 + H_2O = 2AgCl +$

BENZO-GLYCOL DI-ACETATE $C_7H_6O,2C_2H_3O_2$. BENZOYL OXY-CHLORIDE C_7H_5O,Cl, liquid of sp. gr. 1.25. Obtained by passing Cl_2 through benzoyl hydride C_7H_5O,H; or by the action of PCl_5 upon benzoic acid. Thus: $HC_7H_5O_2 + PCl_5 = HCl + POCl_3 + C_7H_5OCl$. (From it Gerhardt made BENZOIC ANHYDRIDE C_7H_5O, C_7H_5O,O.) Heated with sodium valerate $NaC_5H_9O_2$ into valerobenzoic anhydride. BENZOIC ALCOHOL C_7H_7HO; an oily liquid, obtained by action of alcoholic solution of potassium hydrate upon benzoyl hydride. $3C_7H_7HO + KHO = 2H_2O + KC_7H_5O_2$ + TOLUOL $2(C_7H_8)$. BENZOINE $C_{14}H_{12}O_2$, is an isomeric modification, remaining from distillation of the oil from almond paste. Fuses at 120°C. BENZILIC ACID $HC_{14}H_{11}O_3$ fuses at 120°C. BENZILE $C_{14}H_{10}O_2$; isomeric with benzoyl. By Cl_2 upon benzoin. BENZOYL $(C_7H_5O)_2$; odour of geranium. The radical of the series. Heated with 2KHO, into potassium benzoate $2(KC_7H_5O_2)$, and H_2 set free. HIPPURIC or GLYCO-BENZOIC ACID $HC_9H_8NO_3$; in needles, soluble in 600 of H_2O. By boiling HCl with hippuric acid, H_2O is assimilated, and it is resolved into GLYCOCINE $C_2H_5NO_2$, and BENZOIC ACID $HC_7H_5O_2$. Hippuric acid is BENZOYL-GLYCOCINE $HC_2H_3(C_7H_5O)NO_2$. When boiled with PbO_2, into $CO_2 + H_2O$ and BENZAMIDE NH_2,C_7H_5O. From benzoyl chloride $2(C_7H_5OCl) + Zn2C_2H_4NO_2 = ZnCl_2 + 2(HC_9H_8NO_3)$. A constituent of the urine of herbivora; formed in quantity when benzoic acid taken internally. Obtained by evaporation of cow urine, and precipitation by HCl. [HYDRIDE OF TOLUYL C_8H_7O,H and TOLUYLIC ACID HC_8H_7OO are homologous with the benzoyl series. TOLUOL or BENZOENE C_7H_8 homologue to benzol. XYLOL C_8H_{10}. CUMOL C_9H_{12}. CYMOL $C_{10}H_{14}$.]

Oils containing sulphur. OIL OF MUSTARD C_3H_5,CNS is ALLYL SULPHO-CYANIDE. Not in the seed, but by a peculiar albuminous matter, aided by H_2O, upon myronic acid. Boils at 148°C. $C_3H_5I + KCNS = KI + C_3H_5,CNS$. OIL OF GARLIC or ALLYL SULPHIDE $(C_3H_5)_2S$. [ALLYL $(C_3H_5)_2$, liquid of sp. gr. 0·684. Prepared from C_3H_5I by Na. ALLYLIC ALCOHOL C_3H_5HO, boils at 103°C. Metameric with acetone.] **The resins and gum-resins.** Insoluble in H_2O, soluble in alcohol, ether, &c. COMMON RESIN or COLOPHONY consists of two isomeric acids, PINIC and SYLVIC $HC_{20}H_{29}O_2$, pinic acid being most soluble in cold alcohol. GALIPOT, from *Pinus maritima*, contains pimaric acid, the isomer of pinic acid. LAC, from *Ficus indica*, &c., in the market as stick-lac, seed-lac, and shellac. GUAIACUM, from *G. officinale*. The resin contains two acids, one of which GUAIACIC ACID $HC_6H_7O_3$, in needles soluble in H_2O. Melts at 316°C. JALAP RESIN consists of two resins, JALAPIN or RHODEORETIN $C_{21}H_{50}O_{16}$, insoluble in ether and PARARHODEORETIN, powerfully acid, with jalap odour and taste. BALSAM OF CAPIVI

contains CAPIVIC ACID, a neutral resin, and an OIL $C_{10}H_{16}$. **Gum resins** are hardened milky exudations from plants. In addition to gum soluble in H_2O, they contain the characteristic resins and oils. Include ASSAFŒTIDA, ALOES, AMMONIACUM, SCAMMONY, MYRRH, &c. AMBER is a fossil resin: contains SUCCINIC ACID $H_2C_4H_4O_4$, already described at p. 89. CAOUTCHOUC in *Jatropha elastica*, &c. A hydro-carbon $C_{10}H_{16}$, soluble in coal-naphtha, in CS_2, ether, turpentine. Melts at about 121°C. Vulcanized, invented by Goodyear, contains S: ebonite is another form of it. GUTTA-PERCHA, from *Isonandra percha*, tough and inelastic; softens below 100°C. Soluble in BENZOL C_6H_6 &c. Insoluble in alcohol and ether; isomeric with india-rubber.

Cyanogen, Hydrocyanic Acid, and Cyanides. — CYANOGEN **CN}CN** or **(CN)$_2$** or **Cy$_2$**. Type of a simple salt-radical like Cl_2, I_2, Br_2, and F_2. Colourless, poisonous gas, with odour of peach blossoms; sp. gr. 1.806. H_2O dissolves four times its bulk; its solution changes into ammonium oxalate, paracyanogen, &c. Under a pressure of 3.6 atmospheres, liquid. Burns with purple flame to CO_2, and N_2 free. By heating $HgCy_2$: paracyanogen formed at same time. Also by passing air over a mixture of red-hot $K_2CO_3 + 4C + N_2 = 2KCN + 3CO$. CYANIDES. **KCy** in deliquescent, colourless cubes. Alkaline reaction: emits odour of prussic acid. Fuses at red heat. KCy is produced when air is passed over a red-hot mixture of $K_2CO_3 + C$. Also when K_2 is heated in Cy_2 or HCy. Also by heating a mixture of potassium ferrocyanide with potassium carbonate. Thus: $\mathbf{K_4FeCy_6} + \mathbf{K_2CO_3} + 2C = 3CO + Fe + \mathbf{6KCy}$. **NH$_4$Cy** colourless, volatile cubes. Very poisonous. Prepared by subliming mixed **KCy + NH$_4$Cl**. **AgCy** white, insoluble in dilute nitric acid, very soluble in NH_3, and soluble cyanides. **KCy,AgCy**, is very soluble, and used in electro-plating. **HgCy$_2$** in rectangular prisms, soluble in 8 parts of H_2O. Made by dissolving HgO in HCy, or from K_4FeCy_6 by mercuric sulphate. Thus: $K_4FeCy_6 + 3HgSO_4 = 3\mathbf{HgCy_2} + 2K_2SO_4 + FeSO_4$. **AuCy**, a lemon-yellow powder, not decomposed even by boiling acids. **KCy,AuCy**, in solution, much used in electro-gilding. **PdCy$_2$**, yellowish-white, soluble as 2KCy,PdCy$_2$, $3H_2O$. CYANOGEN and HYDROGEN. HYDROCYANIC ACID **HCN** or **HCy**. Commonly called *prussic acid*. 1782, by Scheele. The anhydrous acid is a colourless, volatile liquid, of sp. gr. 0.7058 at 5°C., boiling at 26°.5C. Feebly acid. Odour as of peach-blossoms. Very poisonous. When inhaled even in small quantities, produces headache, giddiness. &c. Antidotes: chlorine, water, ammonia, affusion of cold H_2O, &c. **HCy** cannot be preserved in the light; deposits a black compound containing H, N, and C; evolves NH_3 also. Mixed with HCl, it solidifies to

$NH_4Cl + HCHO_2$. $\mathbf{NH_4CHO_2}$ by heat at 200°C., into HCy + $2H_2O$. *Prep.* Of ANHYDROUS ACID. $Hg\mathbf{Cy_2} + \mathbf{H_2}S = HgS + 2\mathbf{HCy}$. The *ordinary acid* of the Pharmacopœia contains 2 per cent. of HCy; best ascertained from AgCy, how much HCy in a solution. The acid keeps better when a few drops of HCl are added. *Prep. a.* From bitter almonds, by the action of synaptase upon amygdalin (p. 92). 17 grains of AMYGDALIN $\mathbf{C_{20}H_{27}NO_{11}, 3H_2O}$, dissolved in one ounce of emulsion of sweet almonds, would yield 1 grain of pure **HCy**. *b.* 100 grains of $H_2C_4H_4O_6$, 44 grains of KCy and 2 ounces of H_2O will, when decanted, yield an acid of required strength. Thus: $\mathbf{H_2}C_4H_4O_6 + \mathbf{KCy} = KHC_4H_4O_6 + \mathbf{HCy}$. *c.* From $K_4FeCy_6, 3H_2O + H_2SO_4$. Thus: $K_4FeCy_6 + 3H_2SO_4 = KFeCy_3 + 3KHSO_4 + 3\mathbf{HCy}$. Tests for prussic acid. Volatility; formation of AgCy; of Prussian blue and ferric sulpho-cyanide.

Ferro- Ferri- Sulpho-cyanogen. Ferrocyanides.—POTASSIUM FERRO-CYANIDE $\mathbf{K_4FeC_6N_6, 3H_2O}$. In large lemon-yellow crystals, derived from an octohedron with square base. Soluble in 4 of cold, and 2 boiling H_2O. Insoluble in alcohol. Not poisonous; purgative. A source of **HCy**. Also of **CO**. Thus: $K_4FeCy_6 + 6H_2O + 6H_2SO_4 = 2K_2SO_4 + FeSO_4 + 3(NH_4)_2SO_4 + 6\mathbf{CO}$. *Prep.* of the salt. *a.* From dry animal matter, at a red heat in contact with fused K_2CO_3, and iron-filings. *b.* From a ferrous salt, mixed with a solution of potassium hydrate, super-saturated with HCy. Most ferro-cyanides white and insoluble. CUPRIC $\mathbf{Cu_2FeCy_6}$ is red-brown. Chief reactions with iron: *a.* With a FERROUS SALT, a greenish-white compound: $K_4FeCy_6 + FeCl_2 = 2KCl + 2(KFeCy_3)$. *b.* With a FERRIC SALT, *Prussian blue:* $3K_4FeCy_6 + 2Fe_2Cl_6 = 12KCl + \mathbf{Fe_4Fe_3Cy_{18}}$. Prussian blue contains $18H_2O$. Fused with potassium carbonate and charcoal, K_4FeCy_6 is the chief source of **KCy**. HYDRO-FERROCYANIC ACID $\mathbf{H_4FeCy_6}$ is tetra-basic. In white scales, which become blue in air; into basic Prussian blue, $Fe_2O_3, Fe_7Cy_{18} + H_2O$. *Prep.* $K_4\mathbf{FeCy_6} + \mathbf{4HCl} = 4KCl + \mathbf{H_4FeCy_6}$. **Ferri-cyanides.** POTASSIUM FERRI-CYANIDE, or red prussiate of potash $\mathbf{K_3FeCy_6}$ or $\mathbf{K_3Fcdy}$. In right-rhombic prisms of red colour, soluble in 4 of cold H_2O, to reddish-green solution. *Prep.* $2K_4FeCy_6 + Cl_2 = 2KCl + 2\mathbf{K_3FeCy_6}$. FERRI-CYANIDES. Reaction on iron most important. No precipitate with per-salts: a bright blue of *Turnbull's blue* $\mathbf{Fe_3Fe_2Cy_{12}, 12H_2O}$, with Ferrous salts. Thus: $2K_3FeCy_6 + 3FeSO_4 = 3K_2SO_4 + \mathbf{Fe_3Fe_2Cy_{12}}$. HYDRO-FERRICYANIC ACID $\mathbf{H_3FeCy_6}$ in red unstable crystals, by decomposing $Pb_3 2FeCy_6$ by $3H_2S$, and evaporation. [**Nitro-prussides.** SODIUM NITRO-PRUSSIDE $\mathbf{Na_4Fe_2Cy_{10}N_2O_2, 4H_2O}$ in ruby-red prisms, soluble in $2\frac{1}{2}$ of cold H_2O. *Prep. a.* By passing N_2O_3 through solution of HYDRO-FERRO-CYANIC ACID. Thus: $2H_3FeCy_6 + N_2O_3 = 2HCy + \mathbf{H_4Fe_2Cy_{10}N_2O_3}$. HYDRO-NITRO-PRUSSIC ACID in

crystals with $2H_2O$.] **Cobalti-cyanides.** POTASSIUM COBALTI-CYANIDE K_3CoCy_6 in yellowish, flattened prisms, isomorphous with Potassium ferri-cyanide. **Chromi-cyanides.** POTASSIUM CHROMI-CYANIDE K_3CrCy_6, brownish-red prisms. **Platino-cyanides.** $K_2PtCy_4,3H_2O$ in transparent rhombic prisms. **Platini-cyanides.** They are double salts of the platino-cyanides with perchloro-platino-cyanide $5K_2PtCy_4.K_2PtCy_4Cl_2.21H_2O$.]

Sulpho-cyanides. POTASSIUM SULPHO-CYANIDE **KCNS** or **KCsy**, in deliquescent prisms, soluble also in C_2H_5HO. *Prep. a.* By fusing KCy with S. *b.* By calcining K_4FeCy_6, with K_2CO_3 and S. NaCsy in the saliva. Soluble sulpho-cyanides produce an intense red colour with ferric salts, bleached by $HgCl_2$, $AuCl_3$, and evolving H_2S when treated with HCl + Zn. HYDRO-SULPHO-CYANIC ACID **HCNS** or **HCsy**, a liquid of pungent odour; crystallizes at —13°C. Boils at 102°C.; very poisonous. *Prep.* From $Hg2CNS$ by H_2S, as an oily fluid. [MELLON C_9N_{12} is the principal portion of the solid residue, obtained by heating the yellow precipitate made by Cl in solutions of sulpho-cyanides, and supposed to be sulpho-cyanogen. It is tri-basic. HYDRO-MELLONIC ACID $H_3C_9N_{13}$. MELAM $C_6H_9N_{11}$ by distilling ammonium sulpho-cyanide. Boiled with dilute KHO into: MELAMINE $C_3H_6N_6$, in colourless crystals, and: AMMELINE $C_3H_5N_5O$ in the mother-liquor, insoluble in H_2O and C_2H_5HO. $C_6H_9N_{11} + H_2O = C_3H_6N_6 + C_3H_5N_5O$.

Ammeline dissolved in H_2SO_4 and diluted with spirit: AMMELID $C_6H_9N_9O_3$ precipitates. Ammelid $-2NH_3$ = CYAMELURIC ACID $C_6H_3N_3O_3$.]

Cyanic, Cyanuric, Fulminic, and Fulminuric Acids. 1. CYANIC ACID **CNO** or **CyO**. **HCNO** is obtained by heating dry CYANURIC ACID, the polymeride of cyanic acid, to redness: $H_3C_3N_3O_3 = 3HCNO$. Limpid, colourless fluid, of pungent, penetrating odour, like acetic acid. By H_2O into $(NH_4)_2CO_3$. Thus: $2HCNO + 3H_2O = CO_2 + (NH_4)_2CO_3$. Spontaneously into solid cyamelid. CYANATES. **KCNO**, crystallizes from alcohol in thin, transparent plates. Its solution in H_2O, at a boiling heat, into ammonium and potassium carbonates. *Prep.* From KCy + PbO = KCyO + Pb. AMMONIUM CYANATE NH_4CyO, is metameric with urea. When a solution of KCyO is mixed with $(NH_4)_2SO_4$ and evaporated, alcohol dissolves out urea.

2. CYANURIC ACID $H_3C_3N_3O_3,2H_2O$, in colourless, oblique rhombic prisms. Little soluble. Very stable. *Prep.* From MELAM $C_6H_9N_{11}$ in H_2SO_4, and subsequently boiling with 20 to 30 parts of H_2O, until on addition of NH_3, no precipitate falls.

3. FULMINIC ACID $H_2C_2N_2O_2$, is not known in a free state. SILVER FULMINATE $Ag_2C_2N_2O_2$, in white, crystalline plates, soluble in 36 of boiling H_2O. Explodes violently when heated or rubbed. Dangerous. *Prep.* From a very acid solution of

$AgNO_3$, by alcohol and heat. Alcohol oxydized in part to oxalic acid and aldehyde, in part combines as nitrous ether. $2AgNO_3 + N_2O_3 + C_2H_5HO = 2H_2O + 2HNO_3 + Ag_2C_2N_2O_2$. MERCURIC FULMINATE $\mathbf{HgC_2N_2O_2.xH_2O}$ resembles the silver salt. Used in percussion caps. 4. FULMINURIC or ISOCYANURIC ACID $\mathbf{HC_3N_3H_2O_3}$ differs only from cyanuric acid by being monobasic.

Urea, Uric Acid, and its products. UREA $\mathbf{CH_4N_2O}$ or $\mathbf{C(NH_2)_2O}$, is a diamine. Metameric with ammonium cyanate. Transparent, colourless, 4-sided prisms, soluble in 1 of cold H_2O. Saline, cooling taste. At 100°C., its aqueous solution into NH_3 and $(NH_4)_2CO_3$. With Cl: $CH_4N_2O + H_2O + 3Cl_2 = 6HCl + N_2 + CO_2$. By $2HNO_2 = CO_2 + 2N_2 + 3H_2O$. In presence of a ferment, becomes ammonium carbonate (p. 112). Urea is metameric with carbamide. It is a salt-base. NITRATE $\mathbf{CH_4N_2O, HNO_3}$, in shiny scales or rhombic prisms, very little soluble in HNO_3. By evaporating urine, which contains 3.1 per cent. of urea, to syrup, and adding its own bulk of HNO_3. Urea from this nitrate by $BaCO_3$; evaporation and solution in boiling C_2H_5HO, in which $Ba2NO_3$ is insoluble. OXALATE $\mathbf{2CH_4N_2O, H_2C_2O_4}$ in transparent prisms. Urea from this oxalate by $CaCO_3$ and evaporation of solution. With mercuric nitrate, urea forms three compounds; $2HgO,N_2O_5,2CH_4N_2O$; $3HgO,N_2O_5,2CH_4N_2O$, and $4HgO,N_2O_5.2CH_4N_2O$. It also unites with HgO and other bases. URIC or LITHIC ACID $\mathbf{H_2C_5H_2N_4O_3}$ is di-basic. A glistening, white powder, very little soluble. H_2SO_4 dissolves it without decomposition. By fusion with K_2CO_3 into carbonate and cyanate. By heat: into HCy, CyO, CO_2, $(NH_4)_2CO_3$ and a nitrogenized coaly residue. Uric acid a product of the organism. Urine contains 0.037 per cent. *Prep. a.* By concentration of urine and addition of HCl. *b.* From the excrement of serpents, which consists of uric acid and ammonium hydrogen urate. Boiled with dilute KHO, filtered, and precipitated by HCl. URATES. $\mathbf{KHC_5H_2N_4O_3}$ soluble in 500 of cold H_2O. $\mathbf{K_2C_5H_2N_4O_3}$, in fine needles, soluble in 44 parts of cold H_2O. $\mathbf{NaHC_5H_2N_4O_3}$ in chalk stones, $\mathbf{NaHC_5H_2N_4O_3,H_2O}$. AMMONIUM HYDROGEN URATE $\mathbf{NH_4HC_5H_2N_4O_3}$ soluble in 1000 of cold H_2O. The commonest form of urinary deposit, soluble in hot H_2O. Also as a calculus. Guano contains much uric acid, and a substance called GUANINE $\mathbf{C_5H_5N_5O}$, a yellow powder, insoluble in water, alcohol, and ether. ALLANTOIN $\mathbf{C_4H_6N_4O_3}$, in the allantoic fluid of fœtal calf. Small, brilliant, prismatic crystals, soluble in 160 parts of water. *Prep.* From uric acid and lead peroxide: $2H_2C_5H_2N_4O_3 + 2PbO_2 + 3H_2O = 2PbC_2O_4 + 2CH_4N_2O + 2C_4H_6N_4O_3$. By heat into ALLANTURIC ACID $\mathbf{C_3H_4N_2O_3}$ and $(NH_4)_2CO_3$. ALLOXAN $\mathbf{C_4H_4N_2O_5,3H_2O}$ in hard, lustrous crystals, very soluble. Also with $3H_2O$ in efflorescent crystals. Forms a deep-blue compound with a ferrous salt and an

alkali. *Prep.* By dissolving uric acid in dilute HNO_3. Thus: $C_5H_4N_4O_3 + 2H_2O + HNO_3 = HNO_2 + CH_4N_2O + C_4H_4N_2O_5$. ALLOXANIC ACID $H_2C_4H_2N_2O_5$ in radiated needles. MESOXALIC ACID $H_2C_3O_5$. Thus $C_4H_4N_2O_5 + H_2O = CH_4N_2O + H_2C_3O_5$. By NH_3, thus: $C_4H_4N_2O_5 + 2NH_3 - 3H_2O = HC_4H_3N_4O_2$. PARABANIC ACID $H_2C_3N_2O_3$, in colourless prisms, soluble in H_2O, and of acid taste. *Prep. a. Alloxan* $C_4H_4N_2O_5 + HNO_3 = CO_2 + HNO_2 + H_2O + H_2C_3N_2O_3$. *b.* Uric acid $C_5H_4N_4O_3 + O_2 + 2H_2O = 2CO_2 + 2NH_3 + H_2C_3N_2O_3$. THIONURIC ACID $H_2C_4H_3N_3O_3SO_3$ white, crystalline, soluble acid. By heat into URAMILE $NH_2,C_4H_2N_2O_3$ or thionuric acid $- SO_3$. *Prep.* Solution of alloxan saturated with SO_2, neutralized with $(NH_4)_2CO_3$ gives ammonium thionurate $(NH_4)_2C_4H_2N_3O_3,SO_3$. Then from lead thionurate by H_2S. ALLOXANTIN $C_8H_4N_4O_7,3H_2O$ is formed by the action of reducing agents upon alloxan. In 4-sided, oblique rhombic prisms, little soluble. Precipitates Ag from solutions. *Prep.* By H_2S through a solution of alloxan: $2(C_4H_2N_2O_4) + H_2 = H_2O + C_8H_4N_4O_7$. DIALURIC ACID $C_4H_4N_2O_4$, also formed from alloxan by reducing agents and heat $C_4H_4N_2O_5 + H_2 = H_2O + C_4H_4N_2O_4$. Dialuric and alloxanic acid are products of the oxydation of BARBITURIC ACID $H_2C_4H_2N_2O_3,2H_2O$. In prisms. By Br_2 into DIBROMO-BARBITURIC ACID $C_4H_2N_2Br_2O_3$. MUREXIDE or AMMONIUM PURPURATE $C_8H_8N_6O_6$, in square prisms, of green metallic lustre. *Prep.* From uramile $C_4H_5N_3O_3$ in H_2O, by HgO. Also thus: Uramile $C_4H_5N_3O_3$ + alloxan $C_4H_4N_2O_5 + NH_3 - 2H_2O = C_8H_8N_6O_6$. Murexide is soluble in KHO to bright purple. Murexan in yellowish scales, by the action of dilute acids upon murexide. It is an impure uramile. The formation of murexide, by the action of HNO_3, upon uric acid, a test for uric acid.

The Alkaloids or natural organic bases. An obvious relation between the alkaloids and NH_3. They possess an alkaline reaction, are bitter, little soluble in H_2O, and easily in boiling alcohol. *a* **Natural bases destitute of oxygen.** CONIN or CONIA $C_8H_{15}N = C_8H_{14},HN$ in *Conium maculatum.* An imide base. Colourless, volatile, poisonous, oily liquid, of sp. gr. 0.89. Oppressive odour. Browns on exposure. Boils at 171°C. Alkaline; neutralizes acids. With HNO_3 a blood-red colour, passing into orange. H_2SO_4 purple, then olive. SPARTEIN $C_{15}H_{26}N_2$ in *Spartium scoparium.* An oily liquid, boils at 288°C. (The plant contains also SCOPARIN $C_{10}H_{11}O_5$.) NICOTIN $C_{10}H_{14}N_2$ in *Nicotiana tabacum* combined with citric and malic acids. From 6 to 7 per cent. in Virginia tobacco; 2 per cent. in Havannah and Maryland. Limpid, colourless, oily liquid, irritating, inflammable. Very soluble; very poisonous. Salt neutral. Chlorine produces a blood-red colour with nicotin. Nicotin belongs to the nitrile bases: C_5H_7 being the equivalent of

3 atoms of H in NH_3. *b.* **Bases containing oxygen.** CINCHONIN $C_{20}H_{24}N_2O$ in quadrilateral prisms. Chiefly in *Cinchona condaminea* or pale bark. Insoluble in ether. Fuses at 165°C. Salts bitter, and precipitated by tannic acid. CINCHONIN SULPHATE $(C_{20}H_{24}N_2O)_2H_2SO_4,2H_2O$ in irregular prisms. $C_{20}H_{24}N_2O,H_2SO_4,3H_2O$ in large rhombic octohedra. CINCHONIDINE $C_{20}H_{24}N_2O$ is isomeric with cinchonin. QUINIA or QUININ $C_{20}H_{24}N_2O_2,3H_2O$ abundant in *Cinchona calisaya*, or yellow bark, combined with kinic and kino-tannic acids. As a powder, or in silken needles, soluble in 350 of H_2O. Soluble in ether. Intensely bitter. A green colour with chlorine water $+NH_3$. SULPHATE $(C_{20}H_{24}N_2O_2)_2H_2SO_4,7H_2O$ is the di-sulphate of pharmacy. In snow-white needles. Fluorescent in solution. When adulterated with salicin, blood-red by H_2SO_4. $C_{20}H_{24}N_2O_2$, H_2SO_4, very soluble. QUINIDIN $C_{20}H_{24}N_2O_2,2H_2O$ is isomeric with quinin. Less soluble in water, and more soluble in ether. ARICIN or CINCHOVATIN $C_{23}H_{27}N_2O_4$ in a white cinchona bark. Strikes a green colour with nitric acid. **Alkaloids of opium.** MORPHIA or MORPHIN $C_{17}H_{19}NO_3.H_2O$ constitutes $\frac{1}{10}$ to $\frac{1}{16}$ of opium. In short, rectangular prisms, soluble in 1000 of cold and 400 of boiling H_2O. Insoluble in ether. Orange-yellow with HNO_3; finally $H_2C_2O_4$. Fe_2Cl_6 a blue colour (if neutral), destroyed by excess of acid. Mixed H_2SO_4 and HNO_3 green. Iodic acid reduced by morphin. Precipitated by tannic acid. MORPHIA HYDROCHLORATE $C_{17}H_{19}NO_3,HCl,3H_2O$ in silken needles, freely soluble in H_2O and C_2H_6O. SULPHATE $(C_{17}H_{19}NO_3)_2H_2SO_4,5H_2O$ in prisms. CODEIN $C_{18}H_{21}NO_3.H_2O$ in rhombic octohedra, soluble in 80 of cold and 17 of boiling H_2O. Soluble in alcohol and ether. THEBAIN or PARAMORPHIN $C_{19}H_{21}NO_3$ in square plates, soluble in H_2O, in alcohol and ether. Red by H_2SO_4. Said to produce tetanic symptoms. PAPAVERIN $C_{20}H_{21}NO_4$ not poisonous. Little soluble in cold alcohol. Blue by H_2SO_4. NARCOTIN $C_{22}H_{23}NO_7,H_2O$ constitutes 6 to 8 per cent. of opium. Nearly insoluble in H_2O, soluble in alcohol and ether. A blood-red colour by mixed H_2SO_4 and HNO_3. [MECONIN $C_{10}H_{10}O_4$ has no basic properties. In prisms, little soluble in cold, freely in boiling H_2O, alcohol, and ether.] NARCEIN $C_{23}H_{29}NO_9$, silken needles soluble in boiling H_2O and alcohol; insoluble in ether. H_2SO_4 red: heated, green. Iodine blue. [MECONIC ACID $H_3C_7HO_7.3H_2O$ described at p. 79, is the acid of opium.] **Alkaloids of strychnos tribe.** STRYCHNIN $C_{21}H_{22}N_2O_2$ in the beans of *Strychnos Ignatii*. and in the fruit and bark of *Strychnos nux vomica*, and in the Upas tree. *Woorara* also from one of the tribe. In square prisms and octohedra, insoluble in absolute alcohol, ether, and the alkalies. H_2O dissolves only $\frac{1}{7000}$. Soluble in dilute alcohol, chloroform, essential oils, &c. Intensely bitter. Yellow by HNO_3; if Brucia present, orange. With $K_2Cr_2O_7 + H_2SO_4$ a purple tint. $AuCl_3$ a brigh

blue. In testing for strychnia, precipitate by NH_3, and agitate with chloroform: all the strychnin will be found in the $CHCl_3$. BRUCIN $C_{23}H_{26}N_2O_4.4H_2O$ oblique rhombic prisms, fusible and more soluble. Bright red by HNO_3; blue if $SnCl_2$ be added. Obtained from *Brucea antidysenterica*, or False Angustura bark. IGASURIN is also contained in nux vomica. **Alkaloids of tea, coffee, and cocoa.** THEIN or CAFFEIN $C_8H_{10}N_4O_2.H_2O$, from 2 to 4 per cent. in tea, and 1 per cent. in coffee. Also in maté and guarana. Silken needles of bitter taste soluble in 100 of cold H_2O. Feeble basic properties. By Cl_2 into AMALIC ACID $C_6H_7N_2O_4$, homologous with alloxantin. CHOLESTROPHAN $C_5H_8N_2O_3$ by oxydation of caffein, corresponds to parabanic acid. Caffein-murexid, by treatment of amalic acid with NH_3. THEOBROMIN $C_7H_8N_4O_2$ in white crystals, less soluble. It is homologous with caffein. **Other alkaloids.** ATROPIN $C_{17}H_{23}NO_3$ in *Atropa belladonna*. Silken needles. Produces dilatation of the pupil of the eye. ACONITIN $C_{30}H_{47}NO_7$ in *Aconitum napellus*. Forms neutral salts. It is very soluble in H_2O. EMETIN in *ipecacuanha*. PIPERIN $C_{17}H_{19}NO_3$ in pepper. Isomeric with morphin. In colourless prisms, nearly insoluble, of acid taste. Fusible at 100°C. PIPERIDIN $C_5H_{10}HN$, oily base of pungent odour. CAPSICIN, DELPHININ, CURARIN, &c. [Allied to the alkaloids, but not poisonous, are: SALICIN $C_{13}H_{18}O_7$ p. 92. POPULIN $C_{20}H_{22}O_8.2H_2O$. PHLORIDZIN $C_{21}H_{24}O_{10}.2H_2O$, soluble in boiling H_2O and in alcohol. GENTIANIN $C_{14}H_{10}O_5$, in golden-yellow needles. SANTONIN $C_{15}H_{18}O_3$, in *Artemisia*. ASPARAGIN $C_4H_8N_2O_3,H_2O$, in the marsh-mallow and in asparagus shoots. Transparent, colourless crystals. Intimate relations between MALIC ACID and ASPARAGIN, $C_4H_8N_2O_3,H_2O + N_2O_3 = H_2C_4H_4O_5 + 2N_2 + 2H_2O$.

Organic bases of artificial origin. Assumed that a body of the character of AMMONIUM NH_4 exists. In its salts 1, 2, 3, and even 4 atoms of H may be replaced by compound radicals containing various proportions of C and H, as by ETHYL C_2H_5, METHYL CH_3, and AMYL C_5H_{11}, so that four different classes of compound ammonium-salts may be produced. In the first three classes, the change by an alkali is analogous to that of ammoniacal salts generally. The bases thus derived have been distinguished as AMIDE BASES (primary monamines), IMIDE BASES (secondary monamines), and NITRILE BASES (tertiary monamines). The following will serve as illustrations:—

Ammonia type: simple molecule.

Simple Molecule.	Ethylamin.	Di-ethylamin.	Tri-ethylamin.
$N\left\{\begin{matrix}H\\H\\H\end{matrix}\right.$	$N\left\{\begin{matrix}(C_2H_5)\\H\\H\end{matrix}\right.$	$N\left\{\begin{matrix}(C_2H_5)\\(C_2H_5)\\H\end{matrix}\right.$	$N\left\{\begin{matrix}(C_2H_5)\\(C_2H_5)\\(C_2H_5)\end{matrix}\right.$

Includes metallic derivatives of NH_3, the organic monamines, and the monamides.

Ammonia type : double molecule.

Double Molecule of Ammonia.	Ethyl-diamin.	Di-ethylamin.	Tri-ethylamin.
$N_2 \left\{ \begin{matrix} H_2 \\ H_2 \\ H_2 \end{matrix} \right.$	$N_2 \left\{ \begin{matrix} (C_2H_4)'' \\ H_2 \\ H_2 \end{matrix} \right.$	$N_2 \left\{ \begin{matrix} (C_2H_4)'' \\ (C_2H_4)'' \\ H_2 \end{matrix} \right.$	$N_2 \left\{ \begin{matrix} (C_2H_4)'' \\ (C_2H_4)'' \\ (C_2H_4)'' \end{matrix} \right.$

Includes also UREAS, and the ORGANIC DIAMIDES.

Of the **treble molecules**, very few known. A natural ALKALOID, also referable to a primary, secondary, or tertiary monamine, in proportion as it absorbs one, two, or three atoms of ethyl, methyl, amyl, &c. MORPHIN is a tertiary amine base, in which $C_{17}H_{19}O_3$ replaces 3 atoms of H. CODEIN is also a tertiary monamine. CONIN is a secondary monamine.

a. ETHYLAMIN $\mathbf{NH_2,C_2H_5}$. A mobile liquid, of sp. gr. 0.6964. Like NH_3 towards salts. *Prep. a.* From ethylamin iodide by CaO. *a.* $2[NH_2(C_2H_5)I] + CaO = 2[NH_2,C_2H_5)] + H_2O + CaI_2$. *b.* $C_2H_5,CNO + 2KHO = K_2CO_3 + \mathbf{NH_2,C_2H_5}$. ETHYL-UREA $\mathbf{CH_3(C_2H_5)N_2O}$, by passing vapour of HCNO into ethyl-amin: $C_2H_7N + HCNO = \mathbf{CH_3(C_2H_5)N_2O}$. It is urea in which one atom of H is replaced by ethyl. Ethyl-urea is very soluble in H_2O and C_2H_5,HO. Boiled with potassium hydrate into ammonia and ethyl-amine: $CH_3(C_2H_5)N_2O + 2KHO = K_2CO_3 + NH_3 + NH_2,C_2H_5$. DI-ETHYLAMIN $\mathbf{NH(C_2H_5)_2}$. Colourless liquid; boils at 57°.5C. Thus: $NH_2C_2H_5 + C_2H_5Br = NH_2(C_2H_5)_2Br$. Then with KHO. With HCNO into DI-ETHYL-UREA $\mathbf{C[N_2H_2(C_2H_5)_2]O}$. TRI-ETHYLAMIN $\mathbf{N(C_2H_5)_3}$. Colourless, alkaline liquid; boils at 91°C. From di-ethylamin by ethyl bromide. TETRETHYL-AMMONIUM HYDRATE $\mathbf{N(C_2H_5)_4HO}$. Colourless liquid, very alkaline. From IODIDE $\mathbf{N(C_2H_5)_4I}$ by Ag_2O. *b.* METHYLAMIN $\mathbf{NH_2CH_3}$. The most soluble of all gases; 1 vol. absorbs 1040 vols. at 12°C. DI-METHYLAMIN $\mathbf{NH(CH_3)_2}$. TRI-METHYLAMIN $\mathbf{N(CH_3)_3}$. TETRA-METHYL-AMMONIUM HYDRATE $\mathbf{N(CH_3)_4HO}$. *c.* AMYLAMIN $\mathbf{NH_2(C_5H_{11})}$, colourless liquid. &c., &c. PHENYL-AMIN or ANILIN $\mathbf{NH_2,C_6H_5}$ or $\mathbf{NC_6H_7}$; oily, colourless liquid, of aromatic taste and vinic odour. Boils at 182°C., and distils. Sp. gr. 1.028. Browns in air. The name from *Indigofera anil.* The dye mauve, or anilin-purple, by mixing solutions of potassium di-chromate with anilin sulphate. By HNO_3 into $H_2O + N_2$ + PHENOL $\mathbf{C_6H_6O}$. Anilin is prepared: 1. By heating phenol with $NH_3 = H_2O + \mathbf{NH_2(C_6H_5)}$. 2. By H_2S upon NITROBENZENE $C_6H_5(NO_2)$. Thus: $C_6H_5(NO)_2 + 3H_2S = S + 2H_2O + \mathbf{NH_2,C_6H_5}$. 3. By KHO upon INDIGO $\mathbf{C_6H_5NO}$. Thus: $C_6H_5NO + H_2O + 4KHO = 2H_2 + 2K_2CO_3 + \mathbf{NH_2,C_6H_5}$. ROSANILIN $\mathbf{C_{20}H_{19}N_3,H_2O}$: by oxydizing agents upon aniline. It is a triamin capable of uniting with 1, 2, and 3 eqs. of acid. ACETATE $\mathbf{C_{20}H_{19}N_3,C_2H_3O_2}$. Anilin + toluidin $.C_7H_9N$ =

rosanilin and H. Thus: $NH_3,C_6H_5 + 2C_7H_9N = 3H_2 + C_{20}H_{19}N_3$. Anilin-blue is a TRIPHENYL-ROSANILIN HYDROCHLORIDE $C_{20}H_{16}N_3(C_6H_5)_3H_2O$. CHRYSANILIN $C_{20}H_{17}N_3$ is yellow. Nitrate insoluble in H_2O. LEUCANILIN $C_{20}H_{21}N_3$; is colourless, and forms colourless salts. Related to indigo. It is prepared by digesting rosanilin hydrochlorate with zinc. CYANILINE $C_7H_7N_2$. NITRANILIN $C_6H_4NO_2.H_2N$. Homologous with aniline are: TOLUYLIN C_7H_9N. XYLYLIN $C_8H_{11}N$. CUMINYLIN $C_9H_{13}N$. CYMINYLIN $C_{10}H_{15}N$. **Mixed bases.** ETHYL-ANILIN $NH(C_2H_5)(C_6H_5)$. Boils at 204°C. DI-ETHYL-ANILIN $N(C_2H_5)_2(C_6H_5)$. Boils at 213°.5C. METHYL-ETHYL-AMYLAMIN $N,(CH_3)(C_2H_5)(C_5H_{11})$ &c., &c. **Polyatomic bases.** ETHYLENE DIAMINE $N_2(C_2H_4)H_4$. Boils at 117°C. DI-ETHYLENE DIAMINE $N_2(C_2H_4)_2H_2$, a crystalline solid. Derivatives. ETHYLENE DI-AMMONIUM IODIDE $[N_2H_8(C_2H_4)]I_2$. DI-ETHYLENE DI-AMMONIUM IODIDE $[N_2H_4(C_2H_4)_2]I_2$.

Bases obtained by the action of Ammonia upon Volatile Oils. FURFURIN $C_{15}H_{12}N_2O_3$ from furfuramide, by the action of NH_3 upon FURFUROL $C_5H_4O_2$, a liquid of yellow colour, with the odour of oil of Cassia. Thus: $3C_5H_4O_2 + 2NH_3 = 3H_2O + C_{15}H_{12}N_2O_3$. AMARINE or BENZOLINE $C_{21}H_{18}N_2$ from HYDROBENZAMIDE $C_{21}H_{18}N_2$; is isomeric therewith. FUCUSINE. THIOSINNAMINE $C_4H_8N_2S$ from oil of black mustard. Thus: $C_3H_5CNS + NH_3 = C_4H_8N_2S$ or $H_2(C_2H_5)N_2CS$. From it, SINNAMINE $C_4H_6N_2$, a basic compound. Thus: $C_4H_8N_2S + HgO = HgS + H_2O + C_4H_6N_2$. SINAPOLIN $C_7H_{12}N_2O$.

Bases from Aldehyde. THIALDIN $C_6H_{13}NS_2$. ALANIN $C_3H_7NO_2$ from aldehyde-ammonia. Thus: $NH_3,C_2H_4O + HCN + HCl + H_2O = NH_4Cl + C_3H_7NO_2$.

Destructive distillation. Bases from Animal Oils. In addition to ANILIN NH_2,C_6H_5. PICOLINE NC_6H_7, a volatile liquid, of sp. gr. 0.955. Boils at 135°C. RETININ or TETRYLIN NH_2,C_4H_9. Boils at 79°.5C. Same composition as BUTYLAMIN NH_2,C_4H_9. PYRIDIN NC_5H_5. LUTIDIN NC_7H_9. COLLIDIN NC_8H_{11}. PYRROL NC_4H_5.

Bases from Coal-tar Oil. Besides ANILIN and PICOLIN, CHINOLIN or LEUCOLIN NC_9H_7: also by destructive distillation of quinine, &c. LEPIDIN $NC_{10}H_9$, CRYPTIDIN $NC_{11}H_{11}$. **Paraffins.** METHANE CH_4, ETHANE C_2H_6, PROPANE C_3H_8, and QUARTANE C_4H_{10}, are gases. Those containing 20 carbon atoms are more or less solid. Paraffin is obtained largely from Boghead and Leeswood cannel, and from peat. Consists of a mixture of several of the higher members of the series C_nH_{2n+2}. Some petroleums contain ethane and propane, which are given off as gases at ordinary temperatures. KREASOTE $C_8H_{10}O_2$ contained in wood smoke, and abundantly in heavy oil of beech-tar. Colourless, viscid fluid, of pungent taste and odour. Sp. gr. 1.057. Boils at 203°C. Absorbs H_2O. Freely soluble in acetic acid, alcohol, ether, &c.

CHRYSENE $C_{18}H_{12}$, PYRENE or ANTHRACENE $C_{14}H_{10}$. Both the former from pitch at high temperatures. Oil of ordinary tar, on distillation, yields TURPENTINE $C_{10}H_{16}$. Most kinds of oil of turpentine are mixtures of two or more isomeric or polymeric hydrocarbons.

Substances in Coal-tar. Coal-oil is a colourless liquid, lighter than H_2O: inflammable, and a great solvent of caoutchouc. It is a mixture: 1. OF VARIOUS HYDROCARBONS, as: BENZOL C_6H_6, TOLUOL C_7H_8, XYLOL C_8H_{10}, CUMOL C_9H_{12}, CYMOL $C_{10}H_{14}$, NAPHTHALIN $C_{10}H_8$; in brilliant crystalline plates. Melts at 79°C.; boils and sublimes at 212°C. Freely soluble in alcohol and ether. [SULPHO-NAPHTHALIC ACID $HC_{10}H_7SO_3$. CHLORO-NAPHTHALIN $C_{10}H_6Cl_2$. With strong nitric acid, naphthalin yields $C_{10}H_7(NO_2)$, $C_{10}H_6(NO_2)_2$, $C_{10}H_5(NO_2)_3$. By the action of ammonium sulphide upon nitro-naphthalin, NAPHTHYLAMIN $NC_{10}H_9$, a powerful base. PHTHALIC ACID or NAPHTHALIC ACID $H_2C_5H_4O_4$ colourless plates, very soluble in alcohol and ether. Distilled with $2CaO = 2CaCO_3 + C_6H_6$.] ANTHRACENE or PARA-NAPHTHALIN $C_{14}H_{10}$; melts at 213°C. 2. OF SMALL QUANTITIES OF BASES: ANILIN C_6H_7N, PICOLIN C_6H_7N, and CHINOLIN C_9H_7N. 3. OF AN ACID PORTION. Consists of: PHENIC or CARBOLIC ACID HC_6H_5O: (phenol, hydrate of phenyl, or phenylic alcohol). Colourless, deliquescent crystals. Sp. gr. 1.065. Melts at 35°C. Boils at 187°C. Coagulates albumen, and is, like kreasote, antiseptic. It is the phenyl alcohol of the series. ANISOL CH_3,C_6H_5O is methyl phenate. A liquid. Boils at 152°C. SULPHO-PHENIC ACID $HC_6H_5SO_4$ resembles sulpho-vinic acid. PHENYL CHLORIDE C_6H_5Cl, a heavy oil. Heated with NH_3 in sealed tubes, phenol yields ANILIN or PHENYLAMIN $NH_2C_6H_5$. TRI-NITROPHENIC ACID $HC_6H_2(NO_2)_3O$. Also called PICRIC or CARBAZOTIC ACID. Prepared from silk, indigo, salicin, &c., by the action of HNO_3. Yellow prisms, very soluble in alcohol. Requires 80 parts of H_2O for solution: intensely bitter. Potassium carbazotate requires 260 parts of H_2O for solution. CHLORO-PICRIN $C(NO_2)Cl_3$. Liquid of sp. gr. 1.665. Boils at 112°C. Resembles oil of mustard. By distilling $CaOCl_2$ with picric acid. OXYPHENIC ACID $C_6H_6O_4$. STYPHNIC ACID $H_2C_6H(NO_2)_3O_2$. Long, yellow prisms; reddens litmus. By the action of HNO_3 of 1.2, upon certain gum-resins. Astringent.

Bituminous bodies. *Asphaltum* is chiefly ASPHALTENE $C_{20}H_{32}O_3$. It is probably oxydized PETROLENE $C_{20}H_{32}$, an oily substance which, in mineral tar, holds asphaltene in solution. MINERAL CAOUTCHOUC is found in the coal measures and in a lead mine at Castleton, in Derbyshire. Naphtha or rock oil is a mixture of hydro-carbons; so also is petroleum. Three components in mineral naphtha: NAPHTHA, boils at 88°C.; NAPHTHENE C_5H_{16}, boils at 115°C.; and NAPHTHOL at 190°C.

Organic colouring matters.—INDIGO, a product of the genus *Indigofera;* also a constituent of certain urines. Not ready formed, but by oxydation. BLUE INDIGO C_8H_5NO, hydrogenized, becomes INDIGOGEN C_8H_7NO. Also by FeH_2O_2. Thus: $2FeH_2O_2 + H_2O + 2C_8H_5NO = Fe_2O_3,2H_2O + 2C_8H_6NO$. (SULPHINDYLIC ACID $HC_8H_4NSO_4$. ISATIN $C_8H_5NO_2$; yellowish-red prisms, easily soluble in boiling H_2O and alcohol. Stains the skin yellow. Heated with solid KHO, anilin distils: $C_8H_5NO_2 + 4KHO = H_2 + 2K_2CO_3 + NH_2,C_6H_5$. [By Cl, indigo into: CHLORISATIN $C_8H_4ClNO_2$, DI-CHLORISATIN $C_8H_3Cl_2NO_2$, TRICHLORANILIN $C_6H_4Cl_3N$, and TRICHLOROPHENIC ACID $HC_6H_2Cl_3O$. HNO_3 oxydizes indigo, and produces TRI-NITRO-PHENIC ACID $HC_6H_2(NO_2)_3O$. If the acid be more dilute, NITRO-PHENIC ACID $HC_6H_4(NO_2)O$ and DI-NITROPHENIC ACID $HC_6H_3(NO_2)_2O$ are formed. ISATHYD $C_8H_6NO_2$, greyish-white, tasteless, insoluble. It is hydrogenized isatin. INDIN $C_{16}H_{10}N_2O_2$. Polymeric with indigo-blue. If indigo boiled with solution of KHO, indigogen and POTASSIUM ISATATE $KC_8H_6NO_3$, result. POTASSIUM ANTHRANILATE $KC_7H_6NO_2$ by the action of MnO_2 upon indigo dissolved in strong solution of KHO: by heating ANTHRANILIC ACID $HC_7H_6NO_2$ = ANILIN $NH_2,C_6H_5 + CO_2$.] **Litmus, Archil** or **Orseille**, and **Cudbear**. In *Roccella tinctoria, Variolaria orcina, Lecanora tartarea*, &c. Contain various acids which yield ORCIN $C_7H_8O_2,H_2O$. Orcin, the true colour-producing body. By NH_3, into ORCEIN $C_7H_7NO_3$. ERYTHRIC ACID $C_{20}H_{22}O_{10}$, in most archil-yielding lichens. Boiled with barium hydrate into: $2BaCO_3$ + ERYTHRITE $C_4H_{10}O_4$ and ORCIN $2(C_7H_8O_2)$. Orcin, by NH_3 and O into orcein: $2C_7H_8O_2 + 2NH_3 + 3O_2 = 4H_2O + 2(C_7H_7NO_3)$. [EVERNIC ACID $C_{17}H_{16}O_7$ in *Evernia prunastri;* by CaH_2O_2 into: $CaCO_3$ + ORCIN $C_7H_8O_2$ and EVERNESIC ACID $C_9H_{10}O_4$. ORSELLIC ACID $C_8H_8O_4$, when archil boiled with milk of lime; by long boiling into CO_2 + orcin $C_7H_8O_2$. PARELLIC ACID $H_2C_{21}H_{14}O_{10},H_2O$ accompanies LECANORIC ACID $C_{16}H_{14}O_7$ in *Lecanora tartarea* and some other lichens.] **Cochineal** from *Coccus cacti*, gives CARMINE. Colouring matter CARMINIC ACID $C_{14}H_{14}O_8$: with dilute HNO_3 into NITRO-COCCUSIC ACID $H_2C_5H_3(NO_2)_3O_3,H_2O$. **Lac dye** is similar to cochineal. **Madder**, from the root of *Rubia tinctorum*, contains a resin: RUBIAN $C_{28}H_{34}O_{15}$ (?) which yields two colouring matters. ALIZARIN $C_{10}H_6O_3,2H_2O$, in red prisms. By HNO_3 into PHTHALIC ACID $H_2C_8H_4O_4$ and OXALIC ACID $H_2C_2O_4$. RUBIACIN $C_{16}H_{11}O_5$ (?) Yellow needles, sparingly soluble. **Safflower**, from the petals of *Carthamus tinctorius* contains a yellow dye of no value., and CARTHAMIN $C_{14}H_{16}O_7$, a red powder. **Brazil wood** from *Cæsalpinia Braziliensis* yields with alcohol BREZILIN $C_{22}H_{20}O_5$. In yellow crystals. With alkalies, purple. **Logwood** from *Hæmatoxylon campechianum*, contains HÆMATOXYLIN $C_{16}H_{14}O_6,3H_2O$.

Yellow 4-sided needles; with alkalies and O, red. Used for dyeing black with alum. **Indian-yellow** or **Purree** contains: PURREIC OR EUXANTHIC ACID $HC_{21}H_{17}O_{11}$. **Soranjee**, from root of *Morinda citrifolia*, contains a yellow dye, MORIN $C_{12}H_8O_5$. *Rhus cotinus*, or young Fustic, contains a different yellow dye. **Saffron**, from *Crocus sativa*, contains CROCIN $C_{15}H_{22}O_8$ (?) **Turmeric**, from *Curcuma longa*, contains CURCUMIN. **Annatto**, from seeds of *Bixa orellana*, contains BIXIN $C_{16}H_{32}O_2$. **Aloes**, by treatment with HNO_3, furnish a yellow dye, CHRYSAMMIC ACID $HC_7H(NO_2)_2O_2$, as well as PICRIC ACID, and two resinoid acids. **Assafœtida**, by treatment with HNO_3 yields: STYPHNIC ACID $H_2C_6H(NO_2)_3O_2$, a yellow dye.

Albuminoid principles.—Repair the muscular and nervous tissues. Soluble and insoluble forms. Destitute of regular structure. All contain nitrogen and sulphur. When oxydized, furnish compounds of the acetic, butyric, and prussic acid group. Readily putrefy: SYNAPTASE, DIASTASE, and PEPSIN are changing albumen. **Albumen** $C_{72}H_{110}M_2N_{18}SO_{22},H_2O$, in the uncoagulated form, exists in white of egg, blood (6.5 per cent.), chyle (2—4), lymph, and all serous exudations; in the brain, kidneys, liver, pancreas. Soluble in dilute alkalies; it coagulates between 60°C. and 77°C. (depending upon degree of concentration). Evaporated below 49°C., a yellowish gum-like mass. Precipitated by strong alcohol; mineral acids; by metaphosphoric acid: by various metallic salts (hence white of egg antidote to $HgCl_2$). HCl dissolves it with splendid blue colour. Forms definite compounds with the alkalies, excess of which prevents coagulation. In eggs 1.5 per cent. of soda; the formula for SODIUM HYDROGEN ALBUMINATE, in white of eggs, according to Lieberkuhn, is $NaHC_{72}H_{110}N_{18}SO_{22},H_2O$. Albumen does not decompose H_2O_2, nor is its aqueous solution precipitated by K_4FeCy_6. In febrile affections, as also in Bright s disease, in the urine; in cholera and in dysentery, in the stools. **Ovalbumen** is gradually precipitated when agitated with ether, and is scarcely soluble in HNO_3; when injected into a vein, it passes unchanged into the urine. It is also precipitated by oil of turpentine. **Paralbumen**, in ovarian cysts, is coagulated by boiling, but cannot be filtered. By $MgSO_4$, it is not precipitated in a weakly alkaline solution. A weak solution is precipitated by CO_2. **Parapeptone** or **syntonin** is insoluble in NaCl, but easily in alkaline solutions, and in HCl. Prepared from fresh meat, well washed with cold water, and the residue mixed with H_2O containing $\frac{1}{100}$ of HCl. The filtered liquid is precipitated by Na_2CO_3, and washed with H_2O, alcohol and ether. Also made by dissolving albumen (not ovalbumen) or fibrin in strong HCl, and precipitating the filtrate by a double volume of water. **Myosin** is soluble in NaCl and in very dilute HCl;

by heat, and alcohol into coagulated albumen. GLOBULIN or CRYSTALLIN, constituting 12 per cent. of the crystalline lens, and VITELLIN in the yolk of an egg (16 per cent.) is identical with myosin. Prepared from well-washed flesh by digestion with solution of NaCl: the filtered liquid is dropped into much distilled water, and the myosin which separates, redissolved in solution of NaCl, and re-precipitated. **Fibrin**, in blood (0.25) increased in rheumatism and pneumonia to 1 and 1.2 per cent.; in lymph (0.04), in chyle (0.07 to 0.7); diminished in anæmia. It is increased by fasting. According to Schmidt, it is formed by contact of fibrino-plastic, with fibrinogenous matters. FIBRINOPLASTIC MATTER is chiefly in red blood-globules, in serum, cellular tissue, and the cornea; FIBRINOGENOUS MATTER, in exudations, in lymph, and in chyle. They resemble myosin. When in contact, they form fibrin, especially at the temperature of the blood. According to Lehmann, blood-fibrin is transitional albumen towards final syntonin. It is more oxydized than albumen. Boiled with HCl, fibrin yields LEUCIN $C_6H_{13}NO_2$, and TYROSIN $C_9H_{11}NO_3$. **Casein** is coagulable by acids and by *rennet*, the inner membrane of the fourth stomach of the calf. Readily soluble in alkalies, and their carbonates. Prepared from milk by treatment with $MgSO_4,7H_2O$, filtration, washing with solution of $MgSO_4$, dissolving the precipitate in water, removing the butter by filtration, and precipitation by $HC_2H_3O_2$. **Legumin**, in pease and beans, is a form of casein. When albuminous substances are treated with a solution of KHO, potassium albuminate is formed. The composition of several albuminoid bodies, deducting the ash, is as follows:—

	Albumen.	Fibrin.	Casein.	Syntonin.
Carbon	53.5	52.7	53.83	54.1
Hydrogen . . .	7.0	6.9	7.15	7.3
Nitrogen . . .	15.5	16.4	15.65	16.1
Oxygen . . .	21.5	22.1	22.52	21.4
Phosphoric acid .	0.9	0.7	—	—
Sulphur . . .	1.6	1.2	0.85	1.1
	100.0	100.0	100.00	100.0

Amyloid substance is a coagulated albumen, which is coloured reddish by iodine, and violet by sulphuric acid and iodine. **Peptone**, in the stomach and small intestines, is soluble in water, insoluble in alcohol and ether, and is not precipitated either by acids or alkalies. It is formed by the gastric juice from all albuminoid substances.

Gelatigenous Principles, including Bone, Teeth, Hair, Nails, &c.

They contain more N, and less C and S than the albuminoid group, and are only met with in animals. GELATIN and CHONDRIN are not ready-formed, but result from the action of boiling water upon the gelatigenous or chondrin-producing tissues. **Gelatin** is obtained from the white fibrous tissue, the cellular tissue, the skin, bones, and the serous membranes, by boiling with water. *Size* from parchment, *glue* from bones, and *isinglass* from the floating bladder of sturgeons, are more or less pure gelatin. It softens and swells in cold water, and dissolves on heating. Insoluble in alcohol and ether. $\frac{1}{100}$ produces a jelly with water. From its solution in $HC_2H_3O_2$, it is not precipitated by K_4Cfy. By tannin, as TANNO-GELATIN, the basis of leather. Also precipitated by $HgCl_2$. By Cl also completely precipitated. By strong alkaline solutions, on boiling, NH_3 is evolved, LEUCIN $\mathbf{C_6H_{13}NO_2}$, and TYROSIN $\mathbf{C_9H_{11}NO_3}$, being formed. Gelatin consists of: **C** 50.4, **H** 6.64, **N** 18.34, **O** and **S** 24.62 per cent. **Chondrin** is coagulated by vegetable acids, lead acetates, and alum solution. When cartilage becomes ossified, it yields gelatin, and not chondrin. *Prep.* By boiling the cornea, or permanent cartilages for some hours with water. Composition: **C** 49.97, **H** 6.63, **N** 14.44, **O** 28.58, and **S** 0.38. **Horny matter: elastin.** Yellow when moist, extensible, becomes brittle on drying. Insoluble in water, NH_3, $HC_2H_3O_2$, or C_2H_5HO. Dissolved and decomposed by strong solution of KHO. Leucine is formed when it is boiled with sulphuric acid. *Prep.* By boiling the Ligamentum nuchæ of cattle with alcohol, ether, water, $HC_2H_3O_2$, and dilute solution of Sodium hydrate. The **skin** contains, in addition to elastin, a substance largely yielding gelatin when boiled with water. **White fibrous tissue** gelatinizes on boiling: **yellow fibrous tissue** does not. In **hair**, from 3 to 5 per cent. of **S**: the colours vary with the colours of the animal oils. $\mathbf{SiO_2}$ in hair and in the feathers of birds. **Silk** consists of SILK-GELATIN $\mathbf{C_{30}H_{50}N_{10}O_{16}}$, soluble in water (33 per cent.) and SERICIN $\mathbf{C_{30}H_{46}N_{10}O_{12}}$. FIBROIN is analogous to sericin, and constitutes the organic matter of **sponges**. CHITIN $\mathbf{C_{17}H_{26}N_2O_{11}}$, constitutes the skeleton of insects. When pure, it is white, soluble in HNO_3 and in HCl. *Prep.* By boiling the elytra of cockchafers in H_2O, in C_2H_5HO, in $HC_2H_3O_2$, $C_4H_{10}O$, and KHO, in succession. Yields glucose when dissolved in H_2SO_4. **Bones** consist of organic matter called OSSEIN, which yields gelatin on boiling, and is rendered stiff by CALCIUM ORTHO-PHOSPHATE $\mathbf{Ca_3 2PO_4}$ (53 per cent. or more), CALCIUM CARBONATE $\mathbf{CaCO_3}$ (11.3 per cent. in human bones), MAGNESIUM PHOSPHATE $\mathbf{MgHPO_4}$ (1.16 per cent.), SODIUM OXIDE and CHLORIDE, and a distinct trace of CALCIUM FLUORIDE $\mathbf{CaF_2}$. The **teeth** are more solid and compact

BONE, but contain less organic matter. **Enamel** of teeth contains from 81-88 per cent. of $Ca_3 2PO_4$ and from 7-8 per cent. of $CaCO_3$, with more CaF_2 than bones: animal matter 2-3 per cent.

[GLYCOCIN, GELATIN-SUGAR or GLYCOCOLL $C_2H_5NO_2$, may be considered as AMID-ACETIC ACID $HC_2H_2(NH_2)O_2$. Obtained by boiling gelatin with solution of KHO; leucine, glycocine, and ammonia are formed. HIPPURIC ACID $HC_9H_8NO_3 + H_2O$ = BENZOIC ACID HC_7H_5OO + GLYCOCINE $C_2H_5NO_2$. It is easily soluble in H_2O, combines with acids, and forms salts by substituting another metal for H. By HNO_2 into GLYCOLIC ACID or OXY-ACETIC ACID $C_2H_3(HO)O_2 + H_2O + N_2$. Glycolic acid, the homologue of lactic acid. SARKOSIN $C_3H_7NO_2$, is METHYL-GLYCOCINE $C_2H_4(CH_3)NO_2$. Isomeric with ALANIN. *Prep.* By boiling kreatin with solution of Barium hydrate. Colourless rhombic prisms; forms soluble salts with acids. KREATIN $C_4H_9N_3O_2,2H_2O$, from juice of raw meat (5 grs. per lb.), and in minute quantities in the urine. Colourless, oblique prisms, soluble in 75 parts of cold H_2O. Scarcely soluble in alcohol and ether. It is a neutral body. By boiling with alkalies, $+ H_2O$, into UREA CH_4N_2O and SARKOSIN $C_3H_7NO_2$. KREATININ $C_4H_7N_3O$, is in minute quantities in flesh, and the urine. By boiling kreatin with mineral acids, it loses a molecule of H_2O, and becomes kreatinin. Colourless prisms with strong alkaline reaction: forms salts. Soluble in 12 of H_2O. INOSITE or MUSCLE-SUGAR $C_6H_{12}O_5,2H_2O$ a variety of glucose, occurring in muscular substance of the heart, &c., in the unripe seed of *Phaseolus vulgaris*, and other plants. Colourless prisms, anhydrous below 100°C. Sweet taste. Does not reduce cupric salts in presence of KHO. INOSINIC ACID $H_2C_{10}H_{12}N_4O_{11}$, a syrupy liquid not soluble in C_2H_5HO. In mother-liquor from flesh, from which the kreatin has been deposited.]

Blood. The source of all nutriment and all secretions. The heat connected with the activity of the respiratory process. 36.°6C., in man, 42.°8 C., in birds. In mammifera and birds, two kinds of blood: *arterial* and *venous*. The FIBRIN of venous blood is *soluble* in solution of KNO_3, and more prone to oxydize. Sp. gr. from 1.053 to 1.057. Alkaline reaction, from Sodium hydrogen albuminate and from Sodium carbonate and phosphate. Peculiar odour or halitus, more developed by H_2SO_4. Coagulates spontaneously into *crassamentum* or *clot* (13 to 14 per cent.) and *serum* or *liquor sanguinis*—an alkaline, highly-albuminous, straw-coloured liquid of sp. gr. 1.027 to 1.029, coagulating at 77°C. Coagulation traced to the action of fibrino-plastic and fibrinogenous substances: by strong agitation, no coagulation, as the fibrin separates in coherent filaments. Under the microscope, the blood seen to be a liquid, in which a multitude of little, round, red discs float: these the BLOOD-DISCS or RED BLOOD-COR-

PUSCLES ($\frac{1}{3200}''$ in diameter and $\frac{1}{12800}''$ in thickness), accompanied by colourless globules, larger and fewer; the *white corpuscles* ($\frac{1}{2500}''$). The corpuscles consist of an envelope containing a fluid in which the red colouring matter of the blood is dissolved.

The chief part of the red globules consists of HAEMATOGLOBIN. Also called HAEMATOCRYSTALLIN. Usually amorphous: but in tetrahedra in the guinea-pig; long 4-sided prisms, in dogs and cats; 6-sided tables, in the squirrel; and 4- to 6-sided rhombic tables, in the goose. With difficulty soluble in water. When heated to 80°C. for some time, haemaglobin breaks up into HAEMATIN $C_{96}H_{102}N_{12}Fe_3O_{18}$, and coagulated albumen. Haemaglobin from arterial blood, is found by spectrum analysis to differ from that of venous, owing to the union of **O** in the arteries (OXY-HAEMAGLOBIN), and its loss in the veins. [HAEMATIN HYDROCHLORATE $C_{96}H_{102}N_{12}Fe_3O_{18},2HCl$. Teichmann's haemin crystals.] Haemaglobin contains 0.7 per cent. of **S**, 0.42 **Fe**, 7.2 **H**, 16 of **N**, 21.5 **O**, and 54.2 of **C**. **Blood** consists of: water 78 to 78.5 per cent., albumen 6.5 to 7, fibrin 0.02 to 0.03, colouring matter 1.19 to 1.33, cholesterin, serolin, a saponified and a phosphorized fat 0.037 to 0.066, sodium albuminate 0.012 to 0.02 per cent., salts and loss, the rest.

Milk. Sp. gr. from 1.018 to 1.045. A transparent fluid, in which float transparent globules of fat, surrounded by an albuminous envelope, which is broken in churning. The following table comprises various kinds of milk:—

	Woman.	Ass.	Cow.	Sheep.	Goat.
Water	88.6	90.5	87.4	85.6	82.0
Butter	2.6	1.4	4.0	4.5	4.5
Lactin and soluble salts.	4.9	6.4	5.0	4.2	4 5
Casein and insoluble salts	3.9	1.7	3.6	5.7	9.0
	100.0	100.0	100.0	100.0	100.0
Sp. gr. varies { from . .	1.030	1.023	1.030	1.035	1.036
Sp. gr. varies { to . .	1.034	1.035	1.035	1.041	

Components of the Brain. Besides 80 per cent. of water and 7 per cent. of uncoagulated albumen, PROTAGON is the chief constituent of nervous substance, and occurs also in white blood cells, in pus cells, in oil of eggs, &c. In fine needles, almost insoluble in ether, easily in warm spirit of wine. Swells up in water like a decoction of starch. Boiled with solution of Barium hydrate, decomposed into glycerin, phosphoric acid, stearic acid, and a non-nitrogenized acid. [By boiling protagon continuously with solution of BaH_2O_2, NEURIN $C_5H_{15}NO$ is obtained.] CHOLESTERIN $C_{26}H_{44}O$. Is also found in the brain and nerves, as in bile and blood. Chief constituent of gall-stones. *See* **Bile**, p. 111.

Secretions and excretions. Mucus, a tough, viscid fluid. Always contains epithelium and mucous cells. MUCIN is the nitrogenized principle. It is not coagulated by boiling, nor precipitated by $HgCl_2$, K_4Cfy, or $Pb_2C_2H_3O_2$. It is precipitated by acetic acid, and hence obtained from saliva. **Saliva** contains about 1 per cent. of solid matter. Has an alkaline reaction, and contains, besides epithelial particles and mucin, PTYALIN, which rapidly changes starch into sugar, SODIUM SULPHOCYANIDE, NaCl, and Calcium phosphate and lactate. **The gastric juice** is a clear, colourless liquid, of sp. gr. 1.002. Acid reaction: contains **HCl**, $HC_3H_5O_3$, $HC_2H_3O_2$, $HC_4H_7O_2$, and $HC_2H_3O_2$. It dissolves albuminoid substances, and changes them into peptones. PEPSIN (0.319 per cent. in man) is the chief albuminous substance; OSMAZOME is another, but insoluble in water. Pepsin resembles mucin, and is precipitated by $Pb_2C_2H_3O_2$ and by C_2H_5HO; also by any granular precipitate. Starch is no longer changed into sugar, when it has passed from the saliva into the acid gastric juice. **The pancreatic fluid** is strongly alkaline, of sp. gr. 1.008, containing 9 per cent. of solid constituents. It contains 1 per cent. of ash (chlorides and phosphates), an albuminous substance *resembling* PTYALIN, besides LEUCIN, GUANIN, XANTHIN, and INOSITE. Coagulated albumen is dissolved, fat changed into glycerin and fatty acid (at 35°C.), and starch into sugar, by the pancreatic fluid. **Chyle** is the fluid of the lacteals; feebly alkaline and milky. Coagulum smaller and weaker than that from blood. Its fibrin soon begins to coagulate when taken from the vessels: the milkiness is due to the very minute particles of fatty matters. **Lymph** is the fluid from the lymphatics. Colourless, alkaline, and coagulates in from 4–20 minutes. It resembles blood without the red blood-globules, and contains much less albumen and fat. **Exsudation fluid**, from serous membranes and cellular tissue, is chiefly serum, with or without fibrin. **Pus**, a creamy or yellowish fluid, the secretion of wounded surfaces, is neutral, and consists of minute fatty globules floating in a serum. The pus serum contains, besides albumen, PYIN, at least in abnormal pus: this latter is precipitated by $HgCl_2$, and by $Pb_2C_2H_3O_2$. Pus globules are distended by very dilute acids and imperfectly dissolved by alkalies, leaving an albuminous cell-membrane. **Bile** is secreted from venous blood by the liver. A greenish, viscid fluid, which darkens on exposure to the air. It is alkaline, of disagreeable odour, freely miscible with water, and of bitter taste. Evaporated at 100°C., and treated with alcohol, the chief portion leaving a thick jelly of MUCUS from the gall-bladder. The alcoholic solution contains COLOURING MATTER and CHOLESTERIN. The colouring matter may be removed by treatment with charcoal: on evaporation to dryness, cholesterin is dissolved and removed by ether. Pure bile resembles gum,

and is very soluble in water and in alcohol: $2PbO,Pb2C_2H_3O_2$ precipitates it completely. On incineration, bile leaves about 11 per cent. of ash, consisting of sodium carbonate, with a little NaCl, and alkaline phosphate. In addition to CHOLESTERIN, bile consists mainly of a mixture of SODIUM SALTS of GLYCOCHOLIC and TAURO-CHOLIC ACIDS. Human bile consists of: water 82–90 per cent.; glyco- and tauro-cholalates 17.7 to 9.2 per cent.; fat and cholesterin 4.7 to 4 per cent.; mucus and colouring matter 2.4 to 1.5 per cent.; and ash 1.1 to 0.6 per cent. 1. CHOLESTERIN $\mathbf{C_{26}H_{43}HO}$, a fatty substance, insoluble in water, freely soluble in hot spirit, and in ether, crystallizing in pearl-white rhomboidal flakes. It is the chief ingredient of gall-stones, and is largely contained in fatty degeneration of the liver. [Heated with H_2SO_4 into H_2O and $C_{26}H_{42}$. Heated at 200°C. with $HC_{18}H_{35}O_2$ into CHOLESTERYL STEARATE $\mathbf{C_{26}H_{43}O,C_{18}H_{35}O} + H_2O$.] 2. GLYCO-CHOLIC ACID $\mathbf{C_{26}H_{43}NO_6}$, in fine white needles, of bitterish-sweet taste, soluble in H_2O and in C_2H_5HO, with strong acid reaction. It is prepared from the sodium salt by H_2SO_4. [When boiled with solution of KHO ($+ \mathbf{H_2O}$), into CHOLIC ACID $\mathbf{C_{24}H_{40}O_5}$ and GLYCOCIN $\mathbf{C_2H_5NO_2}$. By H_2SO_4 into CHOLOIDIC ACID $\mathbf{C_{24}H_{38}O_4}$ (cholic acid $- H_2O$), and glycocine: if the boiling be longer continued, into DYSLYSIN $\mathbf{C_{24}H_{36}O_3}$. 3. TAURO-CHOLIC ACID $\mathbf{C_{26}H_{45}NSO_7}$. After precipitation of lead glycocholate by $Pb2C_2H_3O_2$, lead taurocholate is thrown down by $2PbO$, $Pb2C_2H_3O_2$, and the acid obtained by H_2S. When boiled with alkalies ($+ H_2O$) into TAURIN $\mathbf{C_2H_7NSO_3}$ and CHOLIC ACID $\mathbf{C_{24}H_{40}O_5}$. [TAURIN $\mathbf{C_2H_7NSO_3}$, in colourless, hexagonal prisms, neutral, tasteless, inodorous. Contains 25 per cent. of S. *Prep.* By long boiling of bile with HCl. Artificially: 1. By heating AMMONIUM ISETHIONATE $C_2H_5(NH_4)SO_4$ at 210°C. into: $H_2O +$ $\mathbf{C_2H_7NSO_3}$. 2. From CHLORETHYLSULPHURIC ACID $C_2H_5ClSO_3$ by digestion at 100°C. with $2NH_3 = NH_4Cl + \mathbf{C_2H_7NSO_3}$. CHOLIC ACID $\mathbf{C_{24}H_{40}O_5}$, in tetrahedra. Soluble in H_2SO_4: on addition of a drop of H_2SO_4 and a solution of sugar (1 to 4 of water), a purple colour is produced (Pettenkofer's test). At 185°C. it loses H_2O, as already stated.] 4. COLOURING MATTERS. CHOLE-PYRRHIN, reddish-brown, uncrystallizable, insoluble in H_2O, more sol. in alcohol. By HNO_3, green, blue, violet, and red; at last, yellow. The amide of BILIVERDIN, which abounds in the bile of Herbivora. BILIFUSCIN $\mathbf{C_{16}H_{26}N_2O_4}$, the chief colouring-matter of human bile, is brown. BILIRUBIN $\mathbf{C_{16}H_{18}N_2O_3}$, is red, and acid. The bile of pigs contains GLYCO-HYOCHOLIC ACID $\mathbf{C_{27}H_{43}NO_5}$. With a molecule of water into: HYOCHOLIC ACID $C_{25}H_{40}O_4 +$ GLYCOCIN $\mathbf{C_2H_5NO_2}$. Contains a little TAURO-HYOCHOLIC ACID $\mathbf{C_{27}H_{45}NSO_6}$. The *Bezoar-stones* of certain goats contain LITHO-FELLIC ACID $\mathbf{HC_{20}H_{33}O_4}$, resembling cholesterin.

The urine.—From arterial blood by the kidneys. Average

sp. gr. 1.02. The quantity passed by an adult from 40 to 50 ounces per day. Amber-coloured, of slight acid reaction, and peculiar odour. It soon begins to putrefy, and becomes alkaline from the conversion of UREA $CH_4N_2O + 2H_2O$ into AMMONIUM CARBONATE $(NH_4)_2CO_3$: the mucus of the bladder acts as a ferment. Besides WATER 95.680 per cent. and UREA 1.420, the urine contains MUCUS 0.016, URIC ACID $H_2C_5H_2N_4O_3$, 0.037, ALCOHOLIC EXTRACT 1.253, AQUEOUS EXTRACT 0.250, SODIUM CHLORIDE 0.722, PHOSPHATES, SULPHATES, &c., 0.613 per cent. The COLOURING MATTERS according to Dr. Schunck, are of two kinds. The most important one is dark-yellow, amorphous, deliquescent, soluble in water, alcohol, and ether. Composition: $C_{42}H_{51}NO_{26}$. At a boiling temperature, into a brown resin and a volatile acid. A second extractive matter insoluble in ether, has a composition $C_{19}H_{27}NO_{14}$. Purpurin or uro-erythrin, which gives the pink colour to the urates, is formed when bile secretion is diminished. INDICAN $C_{26}H_{31}NO_{17}$ is also sometimes present in the urine; after fermentation, or addition of acids, the urine sometimes deposits INDIGO BLUE C_8H_5NO, or its isomer INDIRUBIN. Indican + $2H_2O = C_8H_5NO$ + INDIGLUCIN $3(C_6H_{10}O_6)$. Amongst the "extracts" we find minute quantities of kreatin and kreatinin, of acids homologous with carbolic and oleic, and traces of hippuric acid. The urine is the chief outlet of the effete nitrogenized tissues. Lehmann secreted 821 grains of urea, and 21.6 grains of uric acid, per 24 hours on an animal diet; on a vegetable diet, 348 grains of urea, and 15.4 grains of uric acid. Sulphates in the urine increase greatly with animal food. All alkaline salts of vegetable acids, taken as such into the stomach, are voided as carbonates. The urine of the carnivora is rich in urea, with but little uric acid: that of herbivora also contains much urea, but HIPPURIC ACID $HC_9H_8NO_3$, in place of uric acid. Hippuric acid is BENZOYL-GLYCOCIN $HC_2H_3(C_7H_5O)NO_2$. From the fresh urine of cows, it is obtained by boiling for a few minutes with milk of lime, straining off the phosphates and excess of CaH_2O_2, neutralizing with HCl, and reducing the liquor by heat to $\frac{1}{8}$ its bulk. On addition of much HCl, hippuric acid crystallizes on cooling in transparent needles, soluble in 600 of water. By long boiling, the hippuric acid of the herbivora, into benzoic acid and glycocin: $HC_9H_8NO_3 + H_2O = HC_7H_5OO + C_2H_5NO_2$. Benzoic acid when taken, is voided as hippuric acid. The deposit, so common in urine, of a pink substance, consists of coloured amorphous urates *soluble* in hot water. In herbivorous animals, the urine is often alkaline and turbid from Calcium and Magnesium carbonates and phosphates.

In certain diseases, ALBUMEN is found in the urine. It is detected on addition of HNO_3, which causes a white cloud, which is permanent when boiled; or, on acidulation with $HC_2H_3O_2$,

by $HgCl_2$. (Mere turbidity on boiling may arise from phosphates; a drop of HNO_3, would then re-dissolve the precipitate. In *diabetes*, the urine contains much GLUCOSE. Even in healthy urine, a distinct trace. In some cases $1\frac{1}{4}$ lb., excreted in 24 hours. Much diminished by animal diet and by opium. Best tests are Trommer's and Fermentation. **The chief calculi** are: 1. URIC ACID $\mathbf{H_2C_5H_2N_4O_3}$. Brownish-red or fawn-coloured. Generally of concentric laminæ. Heated to redness, emits an animal odour, carbonizes, and is almost entirely, or entirely consumed. It is soluble in KHO on boiling, and precipitated by HCl as a white powder. Heated with HNO_3, it is dissolved with effervescence, leaving a red residue, rendered crimson or pink by NH_3, and purple by KHO. 2. AMMONIUM URATE $\mathbf{NH_4HC_5H_2N_4O_3}$, is more rare. It is clay-coloured and smooth, and deposited in fine concentric layers. It dissolves in KHO with evolution of NH_3; otherwise like $H_2C_5H_2N_4O_3$. 3. **Calcium oxalate** $\mathbf{CaC_2O_4}$. Also *mulberry calculus*, from its sometimes even blood-red colour. Very dense and hard; deeply tuberculated and rough. When heated, it darkens, diminishes but little in quantity, and leaves a white or grey ash which *effervesces* on addition of acid, and is not precipitated by NH_3. Not soluble in $HC_2H_3O_2$. 4. CALCIUM ORTHO-PHOSPHATE $\mathbf{Ca_3 2PO_4}$, pale-brown, smooth, laminated: very rare. Infusible before the blowpipe flame. Soluble in HCl and precipitated by NH_3. AMMONIUM MAGNESIUM PHOSPHATE $\mathbf{NH_4MgPO_4}$. Or *triple phosphate*. White, brittle, more or less crystalline; surface uneven. Seldom laminated. Fuses with difficulty; not blackening when heated, nor diminishing much in quantity. Heated with KHO, evolves NH_3. Dissolves in HCl without effervescence, and is precipitated by NH_3, as white, crystalline, $NH_4MgPO_4,6H_2O$. FUSIBLE CALCULUS is a mixture of the two former. In white, friable masses, rarely laminated. It fuses readily before the blowpipe flame. XANTHIC OXIDE $\mathbf{C_5H_4N_4O_2}$. Pale brown, polished, lamellar in structure. Very rare. Soluble in KHO, and precipitated on neutralization as a white powder, insoluble in water, alcohol, and ether. Soluble in HNO_3, without effervescence, and leaves on evaporation a lemon-yellow residue. With HgO, it forms an insoluble compound. [HYPOXANTHIN $\mathbf{C_5H_4N_4O}$, in the spleen of man, and of the cow, and in the thyroid and thymus glands. It is white, and *soluble* in HCl.] CYSTIN or CYSTIC OXIDE, $\mathbf{C_3H_6NSO_2}$. Semi-transparent, brownish, crystalline. Insoluble in water, alcohol, and ether, but is soluble in HCl, H_2SO_4, and H_3PO_4. Freely soluble in alkalies and their carbonates From spontaneous evaporation of its solution in NH_3, in hexagonal plates. Emits a fœtid odour on heating.

In the **urine of dogs**, KYNURENIC ACID. Light, silken, colourless needles, insoluble in water, alcohol, and ether.

The **solid excrements** or **fæces** contain about $\frac{3}{4}$ water, the rest consisting of biliary matter and alimentary débris. According to Liebig, about $5\frac{1}{2}$ oz. are excreted in 24 hours by a healthy adult. The odour is the more disgusting as the quantity of bile diminishes. Dr. Marcet has discovered EXCRETIN $\mathbf{C_{78}H_{156}SO_2}$, a peculiar crystallizable principle: it is feebly alkaline, fuses at 94°C., and is insoluble in H_2O.

Respiration. In an ordinary expiration from 30 to 43 cubic inches of air are exhaled: the number of respirations in a healthy adult averages from 14 to 15 per minute. The proportion of $\mathbf{CO_2}$, exhaled, to the **O** inhaled, is much greater in the day than in the night; with perfect rest day and night, nearly twice as much; with active motion during the day, nearly three times as much. The respiratory process is most active in spring. The quantity of CO_2, is very variable, from 3.5 to 6 per cent.; somewhat less of CO_2, is evolved than of O inspired. 8.5 oz. of **C** are respired as $\mathbf{CO_2}$. Birds evolve of CO_2, half as much again as the Mammalia do. The average quantity of $\mathbf{H_2O}$ evolved as vapour is 1 lb. from the lungs, and $1\frac{1}{2}$ lb. from the skin.

APPENDIX.

Therapeutics and Doses of the Chief Chemical Preparations in the 'Materia Medica.'

Extracted from Garrod's 'Materia Medica,'

by H. B. Donkin, Esq., B.A., Oxon.

Aluminum. Al.

ALUM. $NH_4Al_2(SO_4)_{12}H_2O$. Acts as an astringent, with direct, and, after absorption, indirect action. Dose: from 10 to 20 grs. As a purgative, in doses from 30 to 60 grs.

Ammonium. NH_4.

LIQUOR AMMONIÆ. NH_4HO. sp. gr. = ·959. A stimulant to the ganglionic and spinal systems. Given in syncope, typhoid fever, and low states of the system generally. Dose: from 10 to 30 min. Used also as an antidote to poisoning from prussic acid, digitalis, tobacco, &c.

AMMONIÆ PHOSPHAS *v.* **Phosphorus.**

AMMONIÆ BROMIDUM *v.* **Bromine.**

Antimony. Sb.

ANTIMONIUM TARTARATUM, or Tartar Emetic. $KSbC_4H_4O_7.H_2O$. Given as a diaphoretic, expectorant, &c.; from $\frac{1}{16}$ gr. to $\frac{1}{8}$ gr.; as a vascular sedative, $\frac{1}{8}$ gr. to 2 grs.; as an emetic, from 1 gr. to 3 grs.

ANTIMONII OXIDUM. Sb_2O_3. Similar in its effects to preceding, but less likely to cause local irritation. Dose: from 1 gr. to 5 grs.

Argentum. Ag.

ARGENTI NITRAS. $AgNO_3$. Used externally as a caustic; internally, as an alterative and astringent to the mucous membrane of the stomach and intestines. Acts also as a nervine tonic. Dose: from $\frac{1}{4}$ gr. to $\frac{1}{2}$ gr. in a pill.

Arsenicum. As.

ACIDUM ARSENIOSUM. An alterative and tonic in diseases of the skin and nervous system. Acts as an anti-periodic in agues and neuralgic affections; also in chorea and epilepsy. Dose, from $\frac{1}{20}$ to $\frac{1}{24}$ gr. Of the *liquor arsenicalis*, 2 min. to 3 min., or even 10 min.

SODÆ ARSENIAS. Similar to preceding, but less liable to produce irritation. Dose: from $\frac{1}{12}$ to $\frac{1}{3}$ gr. Of the *liquor sodæ arsenicalis*, 5 to 10 min.

Atropia. $C_{17}H_{23}NO_3$.

An alkaloid prepared from the root of Atropa Belladonna.

Given internally in *Extractum Belladonnæ* in doses from ⅛ gr. to 1 gr., and in *Tinctura Belladonnæ* in doses from 5 min. to 30 min., for the purpose of allaying pain and spasm in neuralgic affections, colic, &c., and spasms of the different sphincters; also in nervous coughs. Externally, the preparations of belladonna are used as pupil-dilators in ophthalmic cases.

Benzoic Acid. $HC_7H_5O_2$.

Used to stimulate the mucous membrane of the bladder, and to produce an alterative effect in cases of chronic inflammation of that organ. Dose: from 10 grs. to 15 grs.

AMMONIÆ BENZOAS. $NH_4C_7H_5O_2$. Same in effect as preceding, but more convenient, being more soluble. Dose: from 10 grs. to 20 grs.

Bismuth. Bi.

BISMUTHI SUBNITRAS. $BiNO_4.H_2O$. A direct sedative to the mucous membrane of the stomach and intestines. It is employed in irritative forms of dyspepsia, with pyrosis; and in chronic vomiting. Dose: from 5 grs. to 20 grs. in powder.

Bromine. Br.

AMMONIÆ BROMIDUM. NH_4Br. Dose: from 2 grs. to 20 grs. Similar in its action to

POTASSII BROMIDUM, KBr, which is given (1) as an alterative, especially in skin affections connected with syphilis; (2) in diseases of the nervous system, *e.g.*, as a soporific; in chorea and epilepsy; and as an anaphrodisiac. Dose: from 5 grs. to 30 grs.

Calcium. Ca.

LIQUOR CALCIS. Acts as an antacid on the intestinal canal, blood, and secretions; also as an astringent, being given in diarrhœa connected with acidity. Dose: from ½ fl. oz. to 2 fl. oz., or more.

MISTURA CRETÆ. 1 fl. oz. to 2 fl. oz.

Camphor. $C_{10}H_{16}O$.

A concrete volatile oil, prepared from the wood of Camphora officinarum. Used in mania and melancholia as a calmative; as an antispasmodic in hysterical and other nervous affections; as a sedative in dysmenorrhœa; and in febrile conditions as a diaphoretic. Dose: from 1 gr. to 10 grs.

AQUA CAMPHORÆ. Dose: 1 fl. oz to 2 fl. oz.

SPIRITUS CAMPHORÆ. Dose: from 10 min. to 30 min.

Carbolic Acid. HC_6H_5O.

Used externally as a stimulant, and even escharotic. It possesses also powerful antiseptic qualities. Internally it is used in some forms of gastric irritation connected with vomiting.

As an external application to ulcers, &c.: 1 part of the acid to 7 or 8 of H_2O. Given internally, in doses from 1 to 3 grs.

Chlorine. Cl.

Used as a stimulant in cases of phthisis and bronchitis.

Also as LIQUOR CHLORI, as a gargle in various diseases of the mouth, as ptyalism, cancrum oris. Dose: from 10 min. to 30 min. freely diluted.

Cinchonine. $C_{20}H_{24}N_2O$.

One of the alkaloids contained in the bark of the *Cinchonæ*. See QUININE.

Citric Acid. $H_3C_6H_5O_7.H_2O$.

Acts as a refrigerant, and allays irritation of the skin. Dose: from 10 grs. to 30 grs., or more.

Conia. $C_8H_{15}N$.

A liquid volatile alkaloid, contained in the leaves, &c., of *Conium maculatum*. Acts as a direct sedative, especially on the spinal cord. Used to allay cough in bronchitis, pertussis, and phthisis.

Dose: of the extract, 2 grs. to 6 grs.;
of the compound pill, 5 grs. to 10 grs.;
of the succus conii, 30 min. to 1 fl. drm.;
of the tincture, 20 min. to 1 fl. drm.

Cuprum. Cu.

CUPRI SULPHAS. $CuSO_4$. An astringent in cases of diarrhœa and dysentery, a tonic in chorea and epilepsy. Dose: $\frac{1}{4}$ gr. to 2 grs.

Ferrum. Fe.

Iron salts are given largely as hæmatinics; they have also a direct influence on the nervous system; *e. g.*, in chorea, neuralgia, and epilepsy. Most of the preparations of iron are astringent, and are used in passive hæmorrhages and mucous discharges.

Dose: of the VINUM FERRI, from 1 fl. drm. to 2 fl. drms.;
of the FERRI CARBONAS SACCHARATA, which is non-astringent, from 5 grs. to 20 grs., or more;
of the FERRI IODIDUM, from 1 gr. to 5 grs.:
N.B.—This drug combines the properties of FE and I. It is given in scrofula, phthisis, rheumatoid arthritis, syphilis combined with cachexia:
of the FERRI SULPHAS, from 1 gr. to 5 grs.;

Dose: of the FERRI PHOSPHAS, from 5 grs. to 10 grs.;
of the FERRI ET AMMONIÆ CITRAS, from 5 grs. to 10 grs.;
of the FERRI ET QUINIÆ CITRAS, from 5 grs. to 10 grs.

Gallic Acid. $H_3C_7H_3O_5.H_2O$.

Acts as an astringent, both directly, and remotely, after absorption.

Dose: from 3 grs. to 20 grs.

Hydrargyrum. Hg.

Acts as a sialagogue, cholagogue, diuretic, and emmenagogue. Given in acute inflammation (esp. iritis), rheumatism, dropsies, and syphilis.

HYDRARGYRI SUBCHLORIDUM, or Calomel. Hg_2Cl_2. As a purgative, from 2 grs. to 5 grs.;
To affect the system, ½ gr. to 1 gr., frequently repeated;
Of the *compound pill*, as an alterative, 5 grs. to 10 grs.

HYDRARGYRI PERCHLORIDUM. $HgCl_2$. As an alterative in chronic affections, as in scaly skin diseases, &c., from $\frac{1}{20}$ gr. to ¼ gr.

Hydrocyanic Acid. HCN.

ACIDUM HYDROCYANICUM DILUTUM. sp. gr. = 0·997. Used chiefly to allay pain and spasm, acting as a direct sedative on the entire functional system.

Dose: from 2 to 5 min.

Iodine. I.

As an external application, an irritant, or vesicant, and in course of time, after absorption, a spanæmic. Used in chronic skin diseases, and over enlarged and indurated parts.

Internally used, it increases the activity of most of the secreting and excreting glands, and is a powerful alterative. Given in scrofula, bronchocele, hypertrophy of liver, uterus, &c.; for the relief of secondary and tertiary syphilitic symptoms, &c.

Dose: of free iodine, ½ gr.; of the tincture, 5 min. to 20 min.; of iodide of potassium (KI), 2 grs. to 10 grs.

Lithium. L.

LITHIÆ CARBONAS. L_2CO_3. Acts as a diuretic, and is valuable as forming a soluble salt with uric acid. Given in chronic gout, calculus.

Dose: from 3 grs. to 6 grs.

Magnesium. Mg.

MAGNESIA LEVIS. An antacid and purgative, useful in diarrhœa.

Dose: as an antacid, from 10 grs. to 20 grs.;
as a purgative, from 20 grs. to 60 grs.

MAGNESIÆ SULPHAS. $MgSO_4$, or Epsom salts. Used as a saline purgative.

Dose: from 120 grs. to ½ oz.

Morphia. $C_{17}H_{19}NO_3$.

The chief alkaloid in opium, imparting to the drug most of its valuable properties. Opium acts at first as a stimulant, and afterwards as a powerful narcotic. It is employed to allay pain and spasm, under any condition of the system; in inflammation, to control diseased action; in fevers, hæmorrhages, &c.

Dose: of OPIUM, ¼ gr. to 3 grs., or more;
of TINCTURE OF OPIUM, 4 min. to 40 min., or more;
of HYDROCHLORATE or ACETATE OF MORPHIA, ⅛ gr. to 1 gr.;
of SOLUTION OF HYDROCHLORATE or ACETATE OF MORPHIA, 10 min. to 60 min.

Nitric Acid. HNO_3.

ACIDUM NITRICUM DILUTUM. Sp. gr. = 1·101. Used as a solvent of phosphatic calculi, by injection into the bladder. Given internally as a refrigerant and tonic, and for preventing phosphatic deposits.

Dose: from 10 min. to 30 min., freely diluted.

ACIDUM NITRO-HYDROCHLORICUM DILUTUM. Sp. gr. = 1·074. Given as a tonic and stomachic in dyspepsia; and in chronic hepatitis. Dose: from 5 min. to 20 min., diluted.

Phosphorus. P.

ACIDUM PHOSPHORICUM DILUTUM. H_3PO_4. sp. gr. = 1·08. Used chiefly as a refrigerant, and in affections connected with the excretion of alkaline urine. Dose: from 10 min. to 30 min., freely diluted.

AMMONIÆ PHOSPHAS. $(NH_4)_2HPO_4$. Used when a tendency to uric acid calculi exists, from its capability of largely dissolving urate of soda.

Dose: from 5 grs. to 20 grs., freely diluted.

Plumbum. Pb.

PLUMBI IODIDUM. PbI_2. Applied externally as a mild stimulant to enlarged scrofulous joints.

PLUMBI ACETAS. $Pb(C_2H_3O_2)_2.3H_2O$. In small doses acts as a sedative and astringent. Given in morbid mucous discharges and hæmorrhages. Dose: from ½ gr. to 3 grs.

PILULA PLUMBI CUM OPIO.

Dose: from 4 grs. to 8 grs.

Potassium. K.

LIQUOR POTASSÆ. KHO. An antacid; a powerful sedative on the mucous membrane of the stomach; and a blood alterant. Dose: from 10 min. to 1 fl. drm., freely diluted.

POTASSÆ CARBONAS. K_2CO_3. Similar to preceding, but less caustic. Dose: from 10 grs. to 20 grs.

POTASSÆ BICARBONAS. $KHCO_3$. An antacid; not sedative. Dose: from 10 grs. to 30 grs.

POTASSÆ ACETAS. $KC_2H_3O_2$.
As a diuretic, 10 grs. to 60 grs.
As a purgative, 120 grs. upwards.

POTASSÆ CITRAS. $K_3C_6H_5O_7$. A valuable saline febrifuge. Dose: from 20 grs. to 60 grs.

POTASSÆ TARTRAS ACIDA. $KHC_4H_4O_6$.
As a refrigerant or diuretic.
Dose: from 20 grs. to 60 grs.
As a hydragogue purgative.
Dose: 120 grs. to 300 grs.

POTASSÆ NITRAS. KNO_3.
A powerful sedative on the heart and vascular system generally.
Dose: from 20 grs. to 30 grs.
As a diuretic and refrigerant.
Dose: from 5 grs. to 20 grs.

Quinia. $C_{20}H_{24}N_2O_2.3H_2O$.
The chief of the cinchona alkaloids, imparting to the bark its most important properties.
The bark is a powerful tonic; exerts a great influence on the nervous system, and is much used as an antiperiodic; and is also given as an astringent.
Dose: of the DECOCTUM CIN. FLAV. 1 fl. oz. to 2 fl. oz.;
of the TINCTURES, 1 fl. drm. to 2 fl. drms.;
of QUINIÆ SULPHAS, 1 gr. to 10 grs. or 20 grs.;
of TINCTURE OF QUININE, 1 drm. to 2 drms.;
of VINUM QUINIÆ, ½ fl. oz. to 1 fl. oz.

Sodium. Na.

SODÆ CARBONAS. Na_2CO_3. Similar in its effects to K_2CO_3, but less caustic.
Dose: from 10 grs. to 30 grs.

SODÆ BICARBONAS. $NaHCO_3$. Similar to the corresponding salt of potash, but is considered to agree better with the stomach.
Dose: from 10 grs. to 60 grs.

SODÆ SULPHAS. Na_2SO_4. A saline purgative; influences the biliary secretion, and, in small doses, acts as a diuretic.
Dose: from ½ oz. to 1 oz.

SODÆ PHOSPHAS. $Na_2HPO_4.12H_2O$.
Given as a mild saline purgative, in doses from ½ oz. to 1 oz.; as a diuretic, from 30 grs. to 120 grs. It also renders the urine alkaline, and aids in the solution of uric acid.

SODÆ BIBORAS. $Na_2B_4O_7.10H_2O$. Acts as a mild alkali on the alimentary canal, and as a sedative to mucous membranes.

Dose: from 10 grs. to 60 grs.

Sulphur. S.

As a stimulant in chronic cutaneous diseases. Dose: from 10 grs. upwards.

As a laxative, from 30 grs. to 60 grs.

ACIDUM SULPHURICUM DILUTUM. H_2SO_4; sp. gr. = 1·094. A refrigerant, tonic, and astringent. Dose: from 5 to 30 min., freely diluted.

ACIDUM SULPHUROSUM. H_2SO_3; sp. gr. = 1·04. Used externally in skin diseases: valuable for its destructive influence on vegetable life.

Strychnia. $C_{21}H_{22}N_2O_2$.

The alkaloid which is the active ingredient in *nux vomica*. The preparations act as powerful stimulants to the spinal cord. It is administered in cases of paralysis; to give tone to the intestines and the muscular system; in cases of hysteria and nervous exhaustion; and in chorea and chronic spasmodic affections.

Dose: of POWDERED NUX VOMICA, 2 grs. to 5 grs.;
of the EXTRACT, $\frac{1}{4}$ gr. to 2 grs.;
of the TINCTURE, 10 min. to 20 min.;
of STRYCHNIA, $\frac{1}{30}$ gr. to $\frac{1}{12}$ gr. or $\frac{1}{8}$ gr.

Tannic Acid. $C_{27}H_{22}O_{17}$.

Acts as a powerful astringent to the mucous membrane of the alimentary canal, and as an indirect astringent after absorption. Given in cases of hæmoptysis, hæmaturia, increased mucous discharges, *e.g.*, diarrhœa and dysenteric affections; also to diminish excessive sweating.

Dose: from 3 grs. to 20 grs.

Zinc. Zn.

ZINCI OXIDUM. ZnO. A tonic for the nervous system, in cases of chorea, epilepsy, hysteria, &c.; and as a general astringent in cases of colliquative sweating.

Dose: from 1 gr. to 10 grs., or more.

ZINCI CHLORIDUM. $ZnCl_2$.

A solution of this (sp. gr. = 2·0) is used as a disinfectant and deodorizer, under the name of Sir W. Burnett's Solution.

ZINCI SULPHAS. $ZnSO_4$.

An astringent and nervine tonic. Dose: from 1 gr. to 5 grs. or 10 grs.

An emetic. Dose: from 10 grs. to 30 grs.

Used also as an injection in ophthalmia, gleet, leucorrhœa, &c. Quantity: from 1 gr. to 10 grs. dissolved in 1 oz. of water.

ZINCI VALERIANAS. $Zn(C_7H_9O_2)_2$.

A nervine tonic and antispasmodic, Given when the combined action of the metal and valerian is desirable, *e.g.*, in hysteria, chorea, epilepsy, headache.

Dose: from ½ gr. to 4 grs.

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